U.S. Army Environmental Center

Bioaccumulation Study At Puffer Pond

Fort Devens Sudbury Training Annex, Maynard, Massachusetts

October 1994
Contract No. DAAA15-90-D-0012
Delivery Order No. 0004
ELIN A009

DISTRIBUTION STATEMENT A
Approved for Public Release
Distribution Unlimited

Prepared for:
Commander
U.S. Army Environmental Center
Aberdeen Proving Ground, Maryland 21010-5401

Prepared by:
ecology and environment, inc.
1700 North Moore Street
Arlington, Virginia 22209

Printed on Recycled Paper

2&7RI1.PM4

AEC Form 45, 1 Feb 93 replaces THAMA Form 45 which is obsolete.

UC6094/RC1262

BIOACCUMULATION STUDY AT PUFFER POND
FORT DEVENS SUDBURY TRAINING ANNEX
MAYNARD, MASSACHUSETTS

Contract No. DAAA15-90-D-0012
Delivery Order No. 0004
ELIN A009

October 1994

Prepared for:

UNITED STATES ARMY ENVIRONMENTAL CENTER
Aberdeen Proving Ground, Maryland 21010-5401

Prepared by:

Ecology and Environment, Inc.
Arlington, Virginia 22209

Lewis A. Welzel, Program Manager

Robert J. King, Project Manager

TABLE OF CONTENTS

Appendix

LIST OF TABLES

LIST OF FIGURES

LIST OF ACRONYMS AND ABBREVIATIONS

ASC	Analytical Services Center
AWQC	Ambient Water Quality Criteria
BAF	Bioaccumulation Factor
COC	Chain-of-Custody
CWA	Clean Water Act
CV	Coefficient of Variation
DDD	Dichlorodiphenyldichloroethane
DDE	Dichlorodiphenyldichloroethylene
DDT	Dichlorodiphenyltrichloroethane
DO	Dissolved Oxygen
DQO	Data Quality Objectives
DWPC	Massachusetts Division of Water Pollution Control
E & E	Ecology and Environment, Inc.
EPA	United States Environmental Protection Agency
ERM	Effects-Range Median
ES&E	Environmental Science and Engineering Laboratories
FDA	U.S. Food and Drug Administration
IRDMIS	Installation Restoration Data Management Information System
MDEP	Massachusetts Department of Environmental Protection
MEP	Master Environmental Plan (Sudbury Annex)
μg/g	Micrograms per Gram
μg/L	Micrograms per Liter
mg/kg	Milligrams per Kilogram
NOAA	National Oceanic and Atmospheric Administration
OHM	OHM Remediation Services Corporation
ppm	Parts Per Million
QAPjP	Quality Assurance Project Plan
QA/QC	Quality Assurance/Quality Control
SDWA	Safe Drinking Water Act
SI	Site Investigation
TAL	Target Analyte List
TCL	Target Compound List
TOC	Total Organic Carbon
USAEC	United States Army Environmental Center (formerly USATHAMA)
USAEHA	United States Army Environmental Hygiene Agency
USATHAMA	United States Army Toxic and Hazardous Materials Agency (now USAEC)
USGS	United States Geological Survey
USFWS	United States Fish and Wildlife Service
WQC	Water Quality Criteria
WQP	Water Quality Parameters

EXECUTIVE SUMMARY

The United States Army Environmental Center (USAEC) tasked Ecology and Environment, Inc., (E & E) to conduct a bioaccumulation study at Puffer Pond to determine whether elevated levels of contaminants, related to the operation and maintenance of the Fort Devens Sudbury Training Annex (the Annex), are present in Puffer Pond fish, relative to a reference pond believed to represent local background conditions. Ministers Pond, a pond similar to Puffer Pond and located off Annex property, was chosen as the reference pond. This study augments data from earlier studies which indicate trace levels of metals and pesticide residues in Puffer Pond fish tissues.

Puffer Pond covers an area of approximately 11.9 hectares and is the largest body of standing water within the Annex boundary. The northern end of Puffer Pond is bounded by an inundated scrub/shrub emergent wetland, with the remainder undeveloped and forested. Ministers Pond is about 4.0 hectares in area and is located approximately three miles northwest of Puffer Pond and outside the Annex boundary. Ministers Pond was selected due to its similar trophic level, morphology, and water quality characteristics, as compared to Puffer Pond, and minimal potential for impact from site-related contaminants.

Fish samples were collected from three trophic levels in each pond: top predators (chain pickerel), forage fish (yellow perch), and bottom feeders (brown bullhead). A total of 24 fish, eight from each trophic level, were collected from Puffer Pond for chemical analysis. A total of 19 fish, eight pickerel, four bullhead, and seven perch, were collected from Ministers Pond for chemical analysis. Surface water and sediment samples were also collected to relate levels of priority pollutant metals and chlorinated and organophosphate pesticides in fish to levels in surface water and sediment. Data were also obtained to characterize water chemistry and the morphology of Puffer Pond and Ministers Pond.

Eight inorganic analytes (arsenic, chromium, copper, lead, mercury, nickel, selenium, and zinc) and the pesticides dichlorodiphenyltrichloroethane (DDT), dichlorodiphenyldichloroethylene (DDE), dichlorodiphenyldichloroethane (DDD), and methoxychlor were all detected in fish tissue from Puffer Pond and Ministers Pond. However, only four chemicals, mercury, zinc, DDD, and DDE, were detected at a sufficiently high frequency to allow statistical comparison between the data sets from the two ponds. Mercury was at statistically higher concentrations in Puffer Pond for two of the three fish species sampled. One fish from Puffer Pond had a mercury concentration of 1.12 milligrams per kilogram (mg/kg) which exceeds the U.S. Food and Drug Administration (FDA) action level of 1.0 mg/kg. The degradation products of DDT (DDD and DDE) were found at statistically higher concentrations in all three fish species tested in Puffer Pond; however, pesticide concentrations in fish from both ponds were below applicable FDA action levels and below the average levels for these compounds reported in national fish surveys. Zinc was statistically higher in Ministers Pond for two of the three species of fish sampled.

Zinc levels in fish from both ponds were generally within the range of regional and nationwide background data.

Analysis of surface water samples revealed levels of arsenic in Puffer Pond up to 2.83 micrograms per liter (μg/L), which exceeds the screening level of 0.018 μg/L for arsenic. Arsenic was not detected in surface water samples from Ministers Pond. The lead concentration in a single Puffer Pond surface water sample exceeded the highest level in the reference pond and slightly exceeded the screening value of 3.2 μg/L. Six sediment samples from Puffer Pond and one from Ministers Pond contained arsenic above the 6 μg/g screening level. In addition four samples from Puffer Pond exceeded the National Oceanographic and Atmospheric Administration (NOAA) effects range low (ERL) value of 33 μg/g.

Mercury was not detected in surface water or sediment at levels above the method detection limit in either Puffer Pond or Ministers Pond.

Several conclusions may be drawn from this bioaccumulation study. The results of this report confirm previous findings that mercury and DDT degradation products are present in Puffer Pond fish tissue. As Puffer Pond and Ministers Pond are relatively acidic ponds in watersheds within or near industrialized areas, both ponds possess the key characteristics associated with bioaccumulation of mercury in fish. Mercury, DDD, and DDE concentrations in some fish species from Puffer Pond are higher than the corresponding chemical concentrations in Ministers Pond, but the levels of these and other chemicals are generally below available regional and national background fish tissue levels. Therefore, the site-related human health and ecological risks associated with the use of Puffer Pond are not likely to be greater than those associated with the use of any other local pond.

1. INTRODUCTION

The United States Army Environmental Center (USAEC) tasked Ecology and Environment, Inc., (E & E) to conduct a bioaccumulation study of Puffer Pond at the Sudbury Training Annex in Maynard, Massachusetts. The work was performed under Delivery Order No. 0004 of Contract No. DAAA15-90-D-0012. This bioaccumulation study augments previous Puffer Pond fish studies conducted in 1991 and 1992* (United States Army Environmental Hygiene Agency (USAEHA) 1991; OHM 1994). It addresses data gaps identified upon review of these investigations, and provides a more detailed description of the extent of contamination at Puffer Pond. More specifically, the purpose of this study is to determine whether site-related contaminants are present in fish from Puffer Pond, and to compare the concentrations of these contaminants to chemical concentrations in fish from reference water bodies representative of local and regional background conditions. This effort constitutes an important step in the study of Puffer Pond as it will help to determine whether there are any potential site-related ecological and human health risks associated with the use of this pond.

As a result of bioaccumulation, fish tissue can reveal the presence of pollutants in waterbodies that may otherwise escape detection through routine monitoring of the water column alone. Bioaccumulation is defined as the uptake and retention of chemicals by living organisms through both direct means (bioconcentration) and indirect means (ingestion). Aquatic organisms such as fish are exposed to pollutants through contaminated water, sediment, and food. A pollutant bioaccumulates in a living organism if the rate of intake of the pollutant is greater than the rate of excretion and/or metabolism. The result is an increase in body burden (concentration in tissue) relative to the exposure concentration in the ambient environment. Contaminants detected in fish not only indicate a potential pollution impact to aquatic life and other wildlife (i.e., through biomagnification up the food chain), but also may represent an important route of human exposure through consumption of contaminated fish and shellfish (United States Environmental Protection Agency (USEPA) 1992a).

Site-related contaminants known to have a potential to bioaccumulate in fish were identified during previous sampling episodes, and included pesticides and mercury. Although health and environmental risks of these chemicals were considered to be negligible (OHM 1994), concern was expressed that large fish were not adequately sampled and that background conditions were not known. This report addresses these data gaps by:

- Collecting large predatory fish, forage fish, and bottom-feeding fish; and
- Sampling those same fish from a reference pond, matched with Puffer Pond for chemical and physical characteristics.

*Note: The study conducted by OHM Remediation Services Corporation (OHM) in 1992 was published in 1994 and is referenced in this document as OHM 1994.

To this end, fish were sampled from Puffer Pond and from Ministers Pond, a background pond with similar water quality characteristics located less than 3 miles from Puffer Pond (Figure 1-1). Concentrations of chemicals in three fish species from the two different ponds will be compared to help determine whether significant contamination exists in Puffer Pond relative to background conditions.

SOURCE: USGS 7.5 Minute Series (Topographic) Quadrangles: Hudson, Massachusetts 1988 and Maynard, Massachusetts 1987.

SCALE

0 ½ 1 Mile

Figure 1 - 1 SITE LOCATION MAP

2. SITE BACKGROUND

This section provides general information on site hydrology and ecology. In addition, previous investigations are summarized. Further information may be found in USAEHA's 1991 Health Risk Study (USAEHA 1991), OHM's Puffer Pond Fish Study (OHM 1994), E & E's Site Investigation Report (E & E 1994b), and the Master Environmental Plan (MEP) for Sudbury Annex (E & E 1994a).

2.1 PUFFER POND

Puffer Pond is a natural pond, most likely of glacial origin. It covers an area of approximately 11.9 hectares and is the largest body of standing water within the facility boundary. The pond has a maximum depth of approximately 1.5 meters. Taylor Brook, the main drainage feature of the Annex, flows into and out of this pond. The land surrounding it is undeveloped and forested with predominantly birch (*Betula spp.*), evergreen (various genera), and white oak (*Quercus alba*). The northern end of the pond is an inundated scrub/shrub emergent wetland.

The waters of Puffer Pond are tannic, owing to the slightly acid condition of the water. Aquatic vegetation consists of yellow water lily (*Nuphor varigatum*), coontail (*Ceratophyllum spp.*), anacharis (*Elodea spp.*) and cattails (*Typha latifolia*). The pond bottom morphology can be described as dark brown to black sandy/silt muck containing coarse organic particulate matter along the shoreline, grading to a more silty muck towards the central, deeper portions of the pond. The sediment collected from the southwest portion of the pond bore a slight odor of hydrogen sulfide suggesting an anoxic condition in a state of reduction. There are no records of historical use of Puffer Pond prior to Army acquisition of the Annex. Since acquisition, uses of the pond have been recreational. The Federal Emergency Management Agency maintains a waterwell on the west shore of the pond for use as an emergency water supply (OHM 1994).

Puffer Pond is an ecologically diverse aquatic habitat supporting numerous species of invertebrates, fish, amphibians, reptiles, mammals, waterfowl, and piscivorous birds. Several important recreational species of fish, including chain pickerel (*Esox niger*), largemouth bass (*Micropterus salmoides*), bluegill (*Lepomis macrochirus*), yellow perch (*Perca flavescns*), black crappie (*Pomoxis nigromaculatus*), and brown bullhead (*Ictalurus nebulosus*) have been identified in the pond (OHM 1994). During the field study for this investigation, piscivorous birds including a belted kingfisher (*Ceryle alcyon*) and two Massachusetts State watch-list species, an osprey (*Pandion haliaetus*) and a great blue heron (*Ardea herodias*), were observed feeding in the pond.

2.2 MINISTERS POND

Ministers Pond, located outside the Annex boundary and approximately three miles northwest of Puffer Pond, was selected as the reference location for the collection of surface water, sediment, and fish tissue samples. The selection of a background location was based on criteria established by the Massachusetts Department of Environmental Protection (MDEP), specifically:

- No or minimal potential for site-related impacts;
- A central Massachusetts location; and
- Similar morphology, pH, alkalinity, trophic status, and watershed characteristics.

An extensive search for an appropriate background location was conducted based on these criteria. Communications with the MDEP indicated that the Massachusetts Division of Water Pollution Control's (MDWPC) fish toxics database was not appropriate for use as a comparison standard for background levels of contaminants in fish since sources of pollution exist within the watersheds from which the fish data were developed. The MDEP recommended four ponds to represent clean water reference data sets: the Sudbury River station upstream of the Nyanza Superfund site, Echo Lake, Walden and Sandy Pond, and Lake Dennison. However, the MDEP did not consider the data sets a primary comparison with Puffer Pond fish due to differences in trophic status or other characteristics of the reference water (MDEP 1992a). Based on the MDEP criteria, E & E reviewed the known characteristics of each of the potential background locations and determined that they were sufficiently different from Puffer Pond to warrant selection of an alternative location for background sampling.

The use of Ministers Pond was suggested by members of a local community group. Following a reconnaissance of the pond and collection of preliminary water chemistry data, Ministers Pond was selected because it exhibits many of the same characteristics as Puffer Pond. Both ponds are shallow, mesotrophic to eutrophic with tannic waters, possess a comparatively low pH, and have adjacent wetlands. The two ponds also have similar drainage patterns and are part of the Assabet River drainage system. Shoreline access to Ministers Pond is limited due to its size and surrounding private properties. Recreational use of the pond by area residents was not observed during the sampling period.

Despite the many similarities between Puffer Pond and Ministers Pond, the two ponds exhibit some of the following important differences:

- Ministers Pond (approximately 3.2 to 4.0 hectares in size) is smaller than Puffer Pond; and
- Unlike Puffer Pond, Ministers Pond has residential properties adjacent to it.

Adjacent residential properties may affect the water quality of Ministers Pond through leaching of septic systems, as well as runoff of fertilizers, pesticides, or other anthropogenic contaminants. Despite these features, Ministers Pond bears the greatest similarity to Puffer Pond of the available nearby water bodies and was, therefore, selected as a suitable reference location.

2.3 SUMMARY OF PREVIOUS INVESTIGATIONS

Two previous ecological investigations have been conducted in Puffer Pond; details of these studies are available in OHM's Puffer Pond Fish Study (OHM 1994). The first study was conducted by the USAEHA in 1991 at the request of the Fort Devens Preventative Medicine Agency (USAEHA 1991). This study was undertaken to determine if contamination was present in fish tissue at levels that might constitute a health risk. This limited study found a mercury concentration of 1.2 micrograms per gram (μg/g) in the one chain pickerel caught. This value slightly exceeded the U.S. Food and Drug Administration (FDA) action level of 1.0 μg/g. As a result, Fort Devens issued a catch-and-release advisory on Puffer Pond. Two decomposition products of the pesticide dichlorodiphenyltrichloroethane (p,p'-DDT), dichlorodiphenyldichloroethane (p,p'-DDD) and dichlorodiphenyldichloro-ethylene (p,p'-DDE), were detected in the brown bullhead and golden shiner (*Notemigonus crysoleucas*) tissues, but at concentrations below the FDA action level of 5.0 μg/g.

A second study of Puffer Pond was conducted in 1992 by OHM for the USAEC (OHM 1994). The investigation was requested to confirm results of the USAEHA study which, due to the limited sample size and inconsistencies in the sampling program, was considered by MDEP to be inconclusive (MDEP 1992b). The OHM study analyzed six fillets each of brown bullhead and black crappie. Whole body analyses were also conducted on smaller fish, including brown bullhead, black crappie, and golden shiner. Analytes detected included metals (cadmium, chromium, copper, lead, mercury, zinc), and organophosphorus pesticides (Diazinon, Ronnel, and Chlorpyrifos). A quantitative exposure and risk assessment determined that risks to fishermen and their families were negligible. However, several factors, including a limited sample size, the lack of large specimens of top predatory fish, and no background samples for comparison purposes, limited the certainty of these conclusions and called for additional study.

3. INVESTIGATIVE METHODS

The current study was conducted to provide a detailed and accurate measure of the extent of site-related contamination of fish in Puffer Pond. The following describes the methods that were used in this study.

3.1 SAMPLING DESIGN

3.1.1 Selection of a Reference Pond

Investigations of contaminants in biota or sediments frequently rely on comparisons of concentrations from reference sites and, where known, to levels documented in scientific literature to be associated with a detrimental effect. However, it is often difficult to determine the degree to which the study site has been affected by naturally occurring contaminants. Water bodies lacking a discernible source of contaminants may contain detectable levels of some substances through atmospheric transport and deposition. In an effort to determine the contribution to Puffer Pond of various contaminants from remote sources, as well as natural sources, Ministers Pond was selected as a reference site based on criteria established by the MDEP. The process by which this selection was made is summarized in Section 2.2 of this report and described in more detail in Section 8.5 of the Field Sampling Plan (E & E 1993).

3.1.2 Sample Size Determination

To determine the minimum sample size required to provide statistically viable data, Data Quality Objectives (DQOs) were developed for the Puffer Pond fish sampling to allow a statistically rigorous comparison to be made with the background data (E & E 1993). The sample size needed to meet DQO performance standards is sensitive to the variability of chemical concentrations. Variability is typically expressed as the coefficient of variation (CV), which is the ratio of the standard deviation to the mean. Prior to sampling, the number of samples needed to meet performance standards for risk assessment were calculated using data on mercury in fish provided by MDEP and statistical criteria recommended by EPA guidance (USEPA 1989, 1992b). The CV for mercury in Massachusetts fish was calculated to range from 16.4 percent to 28.7 percent. Assuming a CV of 30 percent, a sample size of seven fish from both the site and background locations was determined to be adequate to detect a difference of 30 percent between the site and background (with a confidence level of 70 percent and a power of 90 percent). However, a sample size of eight was targeted to provide a margin of error should the CV of the samples exceed 30 percent. Therefore, it was determined that a total of 24 fish samples, eight from each of the three trophic levels, would be collected from each pond.

3.2 FISH SAMPLING

3.2.1 Sampling Procedure

Fish samples were collected from Puffer Pond and Ministers Pond between 2 November and 10 November 1993 by experienced fisheries biologists. This collection activity was completed under a scientific collectors permit, obtained for the field team from the Massachusetts Division of Fisheries and Wildlife (No. 120.93.SCF) (Appendix B). A State of Massachusetts fishing license was obtained for each member of the field team prior to fish collection.

To allow for the greatest relevance to potential human and ecological risk, fish samples were collected from three trophic levels:

- Bottom feeders (brown bullhead),
- Forage fish (yellow perch), and
- Top predators (chain pickerel).

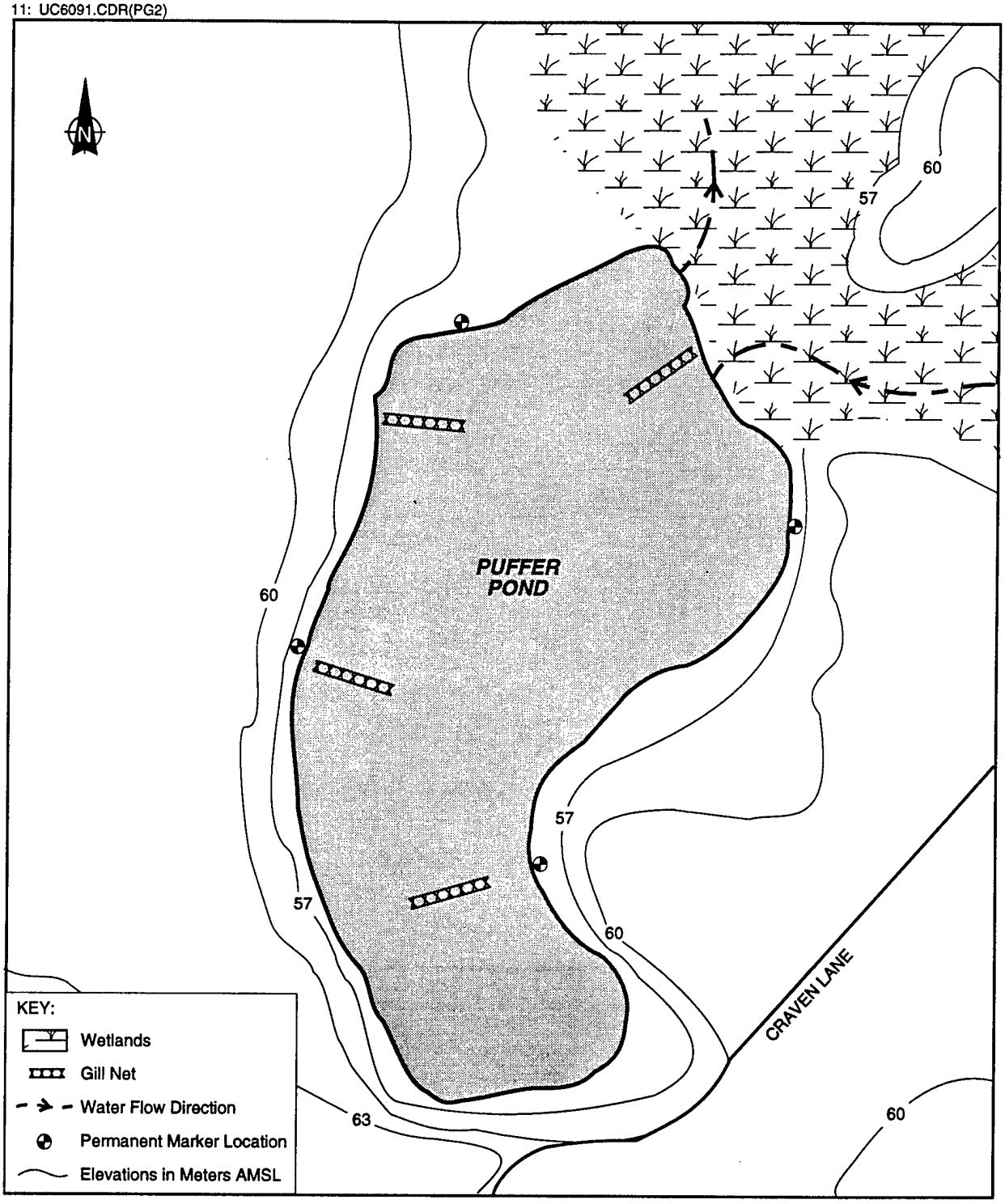
A range of body sizes was included in the collection. Further, a concerted effort was made to collect several larger predatory and bottom-feeding individuals that would be expected to have the highest levels of bioaccumulative substances.

Both active and passive fish collection methods were used, including: gill netting, electroshocking, and angling. Prior to sample collection, a visual survey of each pond was conducted in order to determine the most appropriate locations to find the target fish species. Four gill nets (100 feet long by 6 feet deep) were placed in a variety of aquatic habitat types in an effort to target certain species (Figures 3-1 and 3-2). Each gill net consisted of four 25-foot long panels of various size mesh and various strength twine. Mesh panel compositions were:

- 1/2-inch mesh with #3 twine,
- 1-inch mesh with #4 twine,
- 1-1/2-inch mesh with #4 twine, and
- 2-inch mesh with #6 twine.

The twine was clear monofilament line. A 30-pound sinking line extended the length of the bottom, and a floating line extended along the top. Each end of the net was anchored with a cinder block, and buoys were placed on the top of each net at the ends and in the middle. Four permanent landmarks were established around each pond and a rangefinder was used to fix each net's location for future reference. The nets were in place 24 hours each day and fish were removed from the nets at least twice daily.

11: UC6091.CDR(PG2)



Source: USGS 7.5 x 15 Minute Series (Topographic) Quadrangle, Maynard, MA 1987.

Scale in Feet
0 250 500

Figure 3-1 PUFFER POND GILL NETTING LOCATIONS

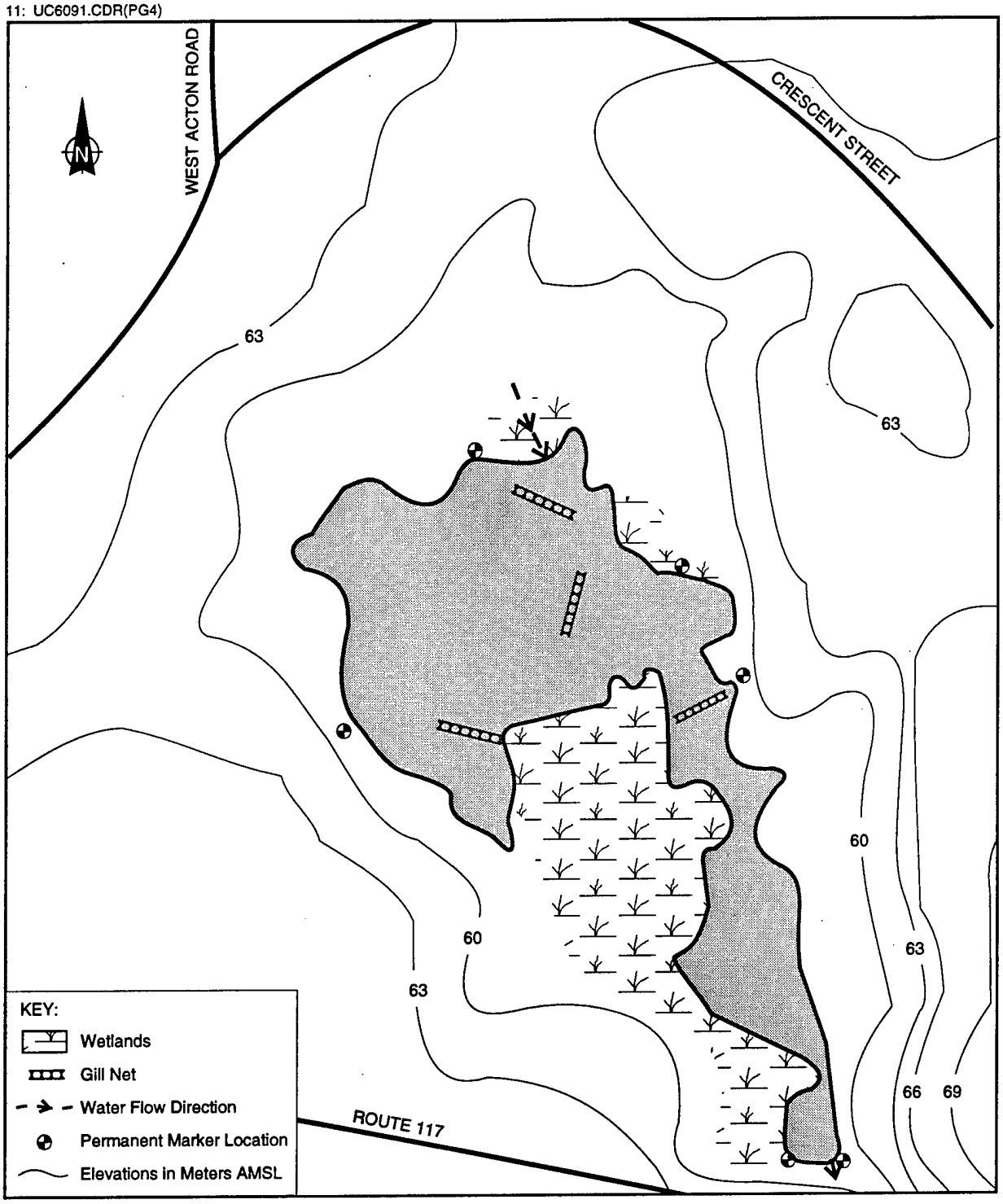


Figure 3-2 MINISTERS POND GILL NETTING LOCATIONS

The electroshocking equipment consisted of a Coffelt Electronics VVPZC 2000 electroshocking unit (comprised of a 5-foot cathode wand, an 8-foot trailing anode, and a 2,250 watt gasoline generator). Electroshocking was conducted in the shallow, littoral zones in each pond, but was not an effective means of capture due to the inadequate conductivity of the waters.

Water quality parameters were measured each day prior to fish collection with a Horiba U-10 water quality meter. Parameters measured included pH, temperature, conductivity, turbidity, and dissolved oxygen.

All fish captured were identified and counted. Target species of sufficient size (based on required tissue volume for analysis) were placed on ice and transported to shore. Non-target species and those not retained for chemical analysis were released. Upon returning to shore, the target fish were visually assayed and any physical abnormalities noted. All weight and length measurements were conducted in the field trailer. The maximum total length of each fish was measured and each fish was weighed to the nearest gram. Aging structures (scales from pickerel and perch, and pectoral spines from bullheads) were removed and archived for future reference. All pertinent data were recorded in the field logbook. The fish were individually wrapped in two layers of aluminum foil and placed in a ziplock bag with a waterproof sample identification tag. The fish were then frozen and stored in a freezer until selections were made for analysis. At that time, the fish samples were shipped on dry ice, under proper chain of custody, to the analytical laboratory.

3.2.2 Sample Preparation and Analysis

To address potential human exposure and risk, analyses were conducted on fillets obtained from the top predator and bottom feeding species using only the edible portion of the fish. Following the MDEP Fish Study guidelines (Appendix A), the skin was removed from the fillets prior to analysis. This is believed to be the most common preparation method used by fishermen and is therefore most representative of a hypothetical user's typical exposure route to potential contaminants in the fish. To address potential ecological risks, the forage fish samples were submitted for whole-body analysis. These fish constitute a primary food source for fish-eating wildlife, such as raccoons and turtles, and are generally consumed whole. The fish tissue samples were analyzed for Target Compound List (TCL) pesticides, Target Analyte List (TAL) metals, organophosphate pesticides, and percent lipids (Table 3-1).

3.3 STATISTICAL ANALYSIS

This section describes the analytical steps and the statistical approach used in this study to determine whether a significant difference exists between the chemical concentrations in fish from Puffer Pond when compared to chemical concentrations in corresponding fish species from the reference pond (Ministers Pond). The strategy was developed based on methods presented in standard statistical textbooks (e.g., Sokal and Rohlf 1981) and EPA guidance for risk assessment (USEPA 1989, 1992b).

Table 3-1

ANALYTICAL PARAMETERS FOR FISH TISSUE SAMPLES

Method	Analyte	Estimated Method Detection Limit (µg/g)
ORGANOPHOSPHORUS PESTICIDES	ATRAZINE	2.5
	VAPONA	4.5
	MALATHION	5.8
	PARATHION	7.3
	SUPONA	2.5
	*CHLORPYRIFOS	5000
	*DIAZANON	5000
	*METHYLPARATHION	5000
	*RONNEL	5000
TCL PESTICIDES	α-BHC	0.009070
	ENDOSULFAN I	0.006020
	ALDRIN	0.007290
	β-BHC	0.002570
	ENDOSULFAN II	0.006630
	CHLORDANE	0.017700
	delta-BHC	0.005550
	DIELDRIN	0.006290
	ENDRIN	0.002400
	ENDRIN ALDEHYDE	0.24000
	ENDOSULFAN SULFATE	0.007630
	HEPTACHLOR	0.006180
	HEPTACHLOR EPOXIDE	0.006200
	ISODRIN	0.004610
	LINDANE	0.006380
	METHOXYCHLOR	0.071100
	p,p'-DDD	0.008260
	p,p'-DDE	0.007650
	p,p'-DDT	0.007070
	TOXAPHENE	0.444000

Table 3-1

ANALYTICAL PARAMETERS FOR FISH TISSUE SAMPLES

Method	Analyte	Estimated Method Detection Limit (µg/g)
TAL METALS	ANTIMONY	0.049
	ARSENIC	0.096
	BERYLLIUM	0.048
	CADMIUM	0.048
	CHROMIUM	0.096
	COPPER	0.494
	LEAD	0.048
	NICKEL	0.096
	SELENIUM	0.191
	SILVER	0.01
	THALLIUM	0.044
	ZINC	0.048
	MERCURY	0.096
PERCENT LIPIDS		NA**

* Denotes compounds that are non-USAEC certified. The detection limits for these compounds are estimates based on laboratory experience.

**Not applicable detection limit for analysis.

Source: Ecology and Environment, Inc., 1994.

For each chemical, the hypothesis to be tested in this study was defined as follows:

- H_0 = Null hypothesis: [Puffer] = [Ministers]. The hypothesis that there is no real difference between the mean concentration of a given chemical in fish from Puffer Pond and the mean of concentration of the same chemical in the corresponding fish species in Ministers Pond.

- H_1 = Alternative Hypothesis: [Puffer] > [Ministers]. The hypothesis that the mean concentration of a given chemical in fish from Puffer Pond is greater than the mean concentration of the same chemical in the corresponding fish species in Ministers Pond.

The following steps were taken to analyze the fish data.

Step 1 - Frequency of Detection Screening

In the first step of the data analysis, the frequency of detection was recorded for each chemical and each fish species. This was done to determine whether chemicals were present in fish in higher frequencies in Puffer Pond compared to Ministers Pond.

Step 2 - Background Screening

Chemical concentrations of fish from both Ministers Pond and Puffer Pond were then compared to reference or background values for chemicals in fish. The frequency of exceedance of background was determined for each chemical and target species. In choosing an appropriate reference concentration, preference was given to data for the target species of fish taken from the four clean waterbodies in central Massachusetts suggested by MDEP (see Section 2.2). If MDEP data were unavailable for a given chemical or species of fish, an alternative reference value was selected from national fish surveys conducted by the United States Fish and Wildlife Service (USFWS) (the National Contaminant Biomonitoring Program, (Lowe *et al.* 1985; Schmitt *et al.* 1990)) or the EPA (the National Study of Chemical Residues in Fish (USEPA 1992a)).

The levels of chemicals in Puffer Pond fish were also compared to the levels of chemicals in the same species of fish from Ministers Pond. For each chemical and target species from Puffer Pond, the frequency of exceedance of the maximum concentration detected in Ministers Pond was determined.

Step 3 - Hypothesis Tests

Data sets with detection frequencies above approximately 50 percent were judged adequate for further statistical comparisons. These data sets were first tested for normality using a graphical method (the rankit method for small samples; Sokal and Rohlf 1981). For normally distributed data, a one-tailed t-test was selected to compare the mean concentrations of chemicals in fish from Puffer Pond and Ministers Pond.

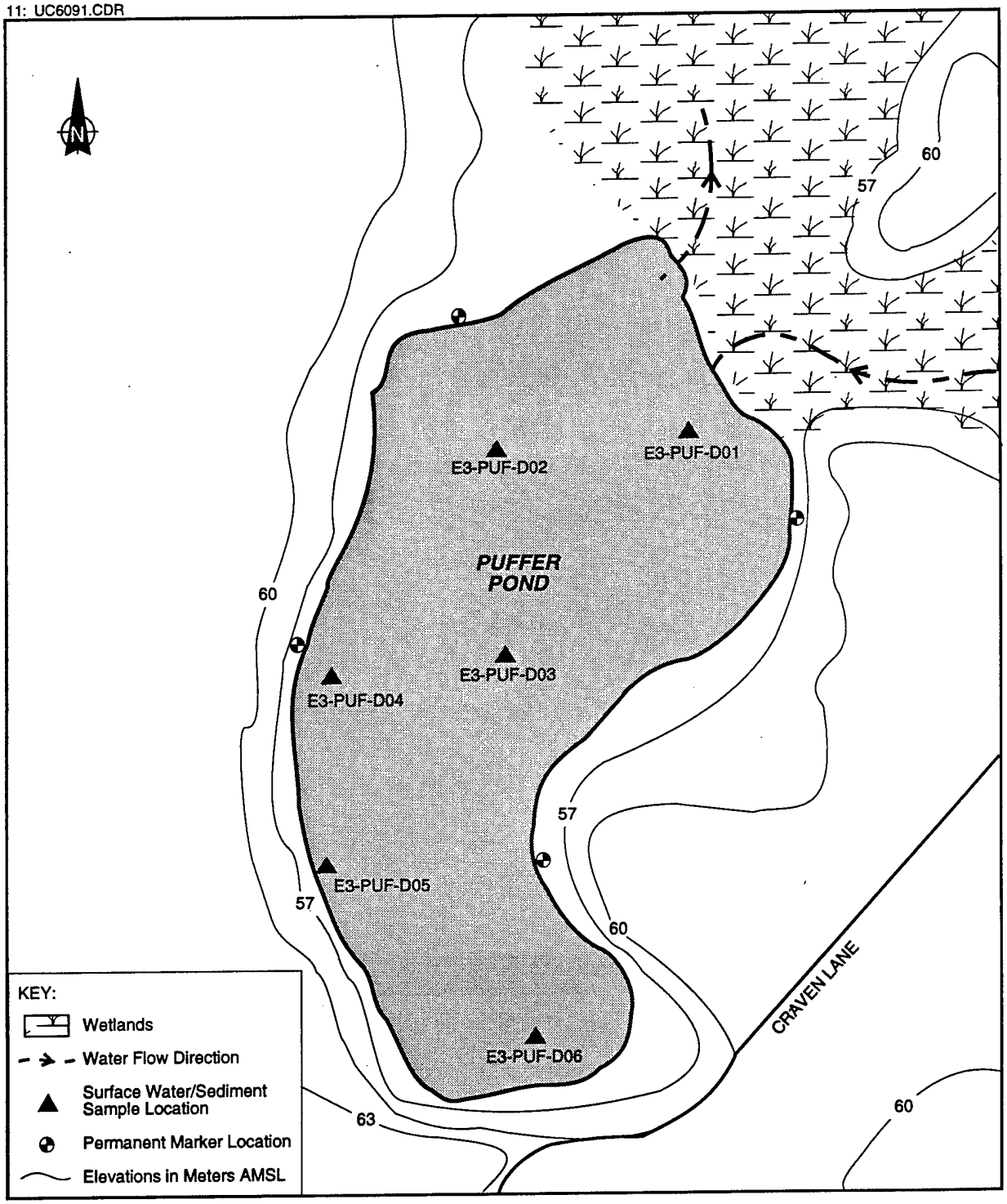
Additionally, because contaminant concentrations in fish can vary with fish size, the lengths and weights of target fish from each pond were statistically compared using t-tests. If significant differences were found, the correlation coefficients of contaminant levels and fish size were calculated. Although some differences in fish size were noted (Section 4), none of the contaminants were found to be statistically correlated with fish size.

Finally, for "censored" data sets consisting of one or more values reported below the detection limit, unbiased estimates of the mean and standard deviation were calculated by "Winsorizing" the data. Winsorizing involves replacing the nondetected values with the lowest concentration detected, simultaneously replacing the maximum concentration with the next highest concentration, and computing the mean and standard deviation on the new data set (Gilbert 1987).

The results of the statistical comparisons are presented as follows: the mean, standard deviation, and coefficient of variation are reported for each data set, and the results of the t-tests are presented as P values. The P value represents the probability that a difference between Puffer Pond and Ministers Pond is due to chance alone. That is, a P less than 0.05 indicates that the null hypothesis of no difference between the two ponds may be rejected with a probability of less than 5 percent that the null hypothesis is correct. Conversely, a P less than 0.05 indicates there is a 95 percent probability or "confidence level" that the difference between the two ponds is real.

3.4 SURFACE WATER AND SEDIMENT SAMPLING

Collocated surface water and sediment samples were collected from six locations in both Puffer Pond and Ministers Pond (Figures 3-3 and 3-4). The samples were collected on 5 November 1993 from Puffer Pond, and on 9 November 1993 from Ministers Pond. At each location, water quality measurements including, pH, temperature, conductivity, turbidity, and dissolved oxygen were taken prior to the collection of the samples. The surface water samples were collected by submerging the prelabeled sample bottles approximately 0.5 meters underwater until filled. The samples were then preserved and placed in a cooler on ice. Sediment samples were collected using a Ponar® dredge sampler which was decontaminated prior to the collection of each sample. For quality assurance/quality control (QA/QC) purposes, a sediment rinsate sample was collected to verify the decontamination procedure and to insure that no cross-contamination of the samples had occurred. The sampling locations were fixed using a rangefinder and permanent markers. The sediment samples were analyzed for TCL pesticides, TAL metals and total organic carbon (TOC). The surface water samples were analyzed for TCL pesticides and TAL metals. All samples were shipped on ice, under proper chain of custody, to the analytical laboratory.



Source: USGS 7.5 x 15 Minute Series (Topographic) Quadrangle, Maynard, MA 1987.

Scale in Feet
0 250 500

Figure 3-3 PUFFER POND SURFACE WATER AND SEDIMENT SAMPLING LOCATIONS

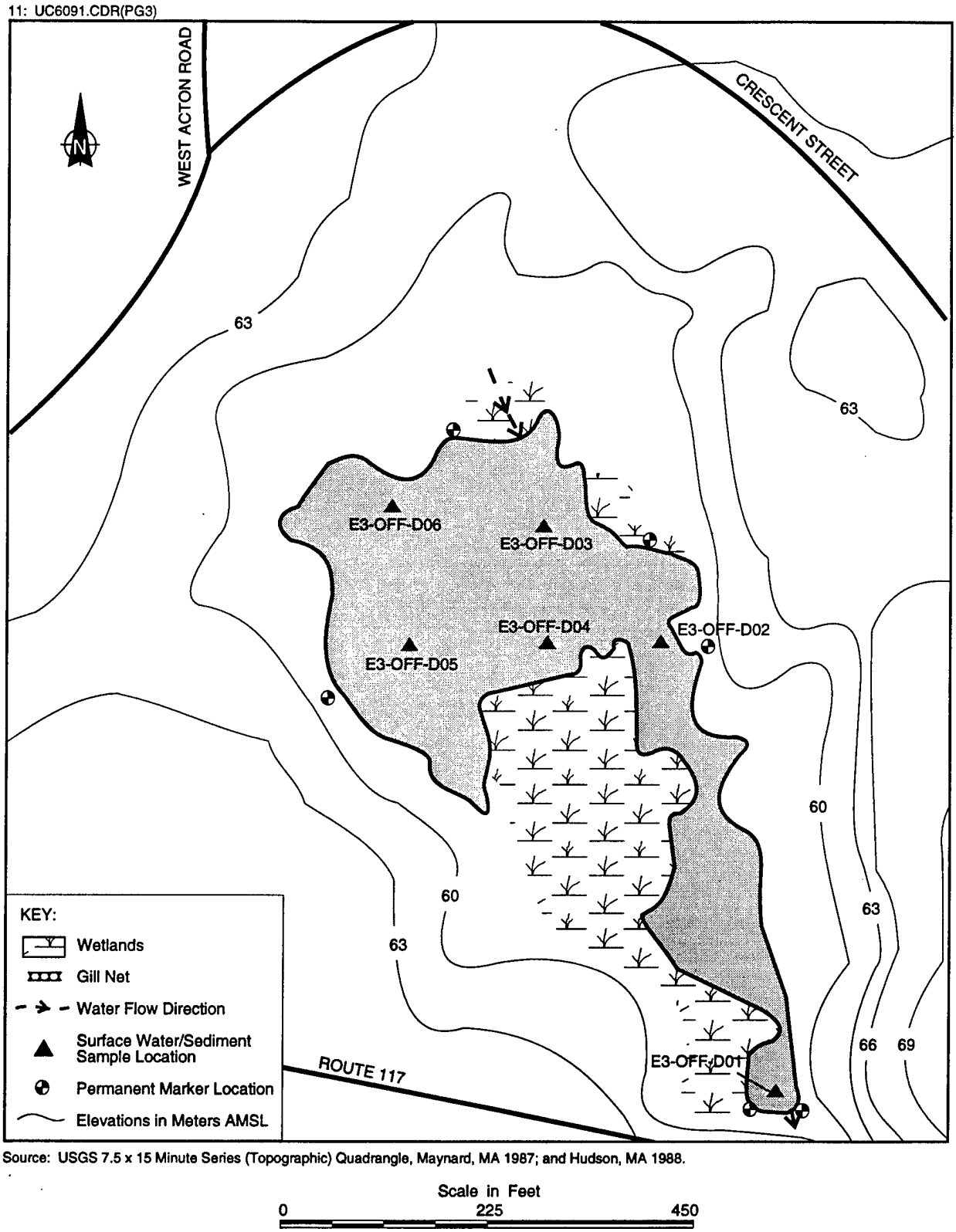


Figure 3-4 MINISTERS POND SURFACE WATER AND SEDIMENT SAMPLING LOCATIONS

4. RESULTS

4.1 DATA USABILITY

Chemical analyses of the fish samples were performed by Environmental Science and Engineering (ES&E) Laboratories according to procedures established in the Quality Assurance Project Plan (QAPjP) for Fort Devens Sudbury Annex (E & E 1993). Procedures were modified from ES&E's certified methods for organophosphorus pesticides, chlorinated pesticides, and TAL metals. Procedures were set in an attempt to achieve detection limits below toxicity values and analyze for all the compounds of concern. Data were submitted to USAEC's Installation Restoration Data Management Information System (IRDMIS) and downloaded into E & E's Site Master Database. All data were reviewed for usability in accordance with procedures established in the work plan (E & E 1993) and employed in the concurrent site investigations performed at the Annex (E & E 1994b). Data usability codes appear on the data summary tables in Appendices C and D. All data were usable for evaluating contaminant levels in fish without qualification.

Chemical analyses of the surface water and sediment samples were performed by ES&E and E & E's Analytical Services Center (ASC) as described in the Phase II Site Investigation Report (E & E 1994b).

4.2 FISH SAMPLING RESULTS

In general, all fish caught during this investigation appeared in good health and were relatively abundant due to the high quality habitat found in both ponds. Numerical data on species of fish caught in Puffer Pond and Ministers Pond are provided in Table 4-1. Faunal composition was similar between the two ponds, the principal differences being the absence of black crappie in Ministers Pond and in general, the relatively large numbers of forage fish (i.e., yellow perch and black crappie) in Puffer Pond relative to Ministers Pond. Target fish species were captured in both ponds. However, only four bullhead of sufficient size for chemical analysis were obtained from Ministers Pond, less than the target sample size of eight. The complete analytical results of fish sampling are presented in Appendix C.

4.2.1 Comparison of Fish Size

Tables 4-2 and 4-3 present the weights and lengths of the fish collected for chemical analysis from the two ponds. After determining that the data are normally distributed using the graphical method described in Section 3, the lengths and weights of the fish from the two ponds were compared using the t-test. Perch from Puffer pond were smaller (length and weight) than perch from Ministers Pond. This result was statistically significant to $P = 0.055$ and $P = 0.019$ for lengths and weights respectively (Table 4-4). However, pickerel were larger in Puffer Pond ($P = 0.107$ and $P = 0.069$ for fish lengths and weights, respectively).

Table 4-1

TOTAL NUMBERS OF FISH CAUGHT BY SPECIES

Common Name	Species	Puffer Pond	Ministers Pond
Chain pickerel	*Esox niger*	25	25
Yellow perch	*Perca flavesens*	23	8
Brown bullhead	*Ictalurus nebulosus*	27	10
Largemouth bass	*Micropterus salmoides*	3	9
Common carp	*Cyprinus carpio*	3	7
Black crappie	*Pomoxis nigromaculatus*	53	0
Pumpkinseed	*Lepomis gibbosus*	1	8
Bluegill	*Lepomis macrochirus*	5	6
Golden shiner	*Notemigonus crysoleucas*	39	112

Source: Ecology and Environment, Inc., 1994.

Table 4-2

FISH SAMPLE COLLECTION DATA FROM PUFFER POND

Sample Number	Sample Type	Species	Length (in)	Wet Weight (g)
FXPUF011	FILLET	PICKEREL	21	981
FXPUF021	FILLET	PICKEREL	16	418
FXPUF031	FILLET	PICKEREL	16.5	396
FXPUF041	FILLET	PICKEREL	16.5	437
FXPUF051	FILLET	PICKEREL	16	384
FXPUF061	FILLET	PICKEREL	18	679
FXPUF071	FILLET	PICKEREL	18	655
FXPUF081	FILLET	PICKEREL	17	507
FXPUF091	FILLET	BULLHEAD	12	362
FXPUF101	FILLET	BULLHEAD	11	311
FXPUF111	FILLET	BULLHEAD	11.5	320
FXPUF121	FILLET	BULLHEAD	12	372
FXPUF131	FILLET	BULLHEAD	11	304
FXPUF141	FILLET	BULLHEAD	12	349
FXPUF151	FILLET	BULLHEAD	11	302
FXPUF161	FILLET	BULLHEAD	11	303
FXPUF171	WHOLE	PERCH	9	135
FXPUF181	WHOLE	PERCH	8.5	113
FXPUF191	WHOLE	PERCH	9	118
FXPUF201	WHOLE	PERCH	8.5	103
FXPUF211	WHOLE	PERCH	8	99
FXPUF221	WHOLE	PERCH	8	93
FXPUF231	WHOLE	PERCH	8	88
FXPUF241	WHOLE	PERCH	8	89

Source: Ecology and Environment, Inc., 1994.

Table 4-3

FISH SAMPLE COLLECTION DATA FROM MINISTERS POND

Sample Number	Sample Type	Species	Length (in)	Wet Weight (g)
FXBCK011	FILLET	PICKEREL	17	523
FXBCK021	FILLET	PICKEREL	15	338
FXBCK031	FILLET	PICKEREL	16	382
FXBCK041	FILLET	PICKEREL	15.5	344
FXBCK051	FILLET	PICKEREL	15.5	353
FXBCK061	FILLET	PICKEREL	16.5	467
FXBCK071	FILLET	PICKEREL	18	483
FXBCK081	FILLET	PICKEREL	18	545
FXBCK091	FILLET	BULLHEAD	9	177
FXBCK101	FILLET	BULLHEAD	10.5	298
FXBCK111	FILLET	BULLHEAD	13	480
FXBCK121	FILLET	BULLHEAD	13.5	530
FXBCK131	WHOLE	PERCH	8	107
FXBCK141	WHOLE	PERCH	8.5	119
FXBCK151	WHOLE	PERCH	9.5	153
FXBCK161	WHOLE	PERCH	9.5	162
FXBCK171	WHOLE	PERCH	9	140
FXBCK181	WHOLE	PERCH	9	144
FXBCK191	WHOLE	PERCH	11.5	258

Source: Ecology and Environment, Inc., 1994.

Table 4-4

COMPARISON OF WEIGHTS AND LENGTHS OF SAMPLED FISH

Fish Lengths (inches)		Species		
		Pickerel	Bullhead	Perch
Sample Number	Puffer Pond	8	8	8
	Ministers Pond	8	4	7
Mean	Puffer Pond	17.4	11.4	7.4
	Ministers Pond	16.4	11.5	9.3
Standard Deviation	Puffer Pond	1.66	0.50	2.81
	Ministers Pond	1.15	2.12	1.11
Coefficient of Variation	Puffer Pond	10%	4%	39%
	Ministers Pond	7%	20%	12%
P (T-test, one-tailed analysis)		0.107	0.479	0.055
Fish Weights (grams)		**Species**		
		Pickerel	**Bullhead**	**Perch**
Sample Number	Puffer Pond	8	8	8
	Ministers Pond	8	4	7
Mean	Puffer Pond	557	328	105
	Ministers Pond	430	371	155
Standard Deviation	Puffer Pond	206	29	16
	Ministers Pond	85	163	49
Coefficient of Variation	Puffer Pond	38%	9%	16%
	Ministers Pond	20%	47%	33%
P (t-test, one-tailed analysis)		0.069	0.317	0.019

Source: Ecology and Environment, Inc. 1994.

The average size of bullhead was larger in Ministers Pond but this difference is not statistically significant.

As noted in Section 3, none of the contaminants were significantly correlated with fish size.

4.2.2 Frequency of Detection Screening

As shown in Tables 4-5 and 4-6, compounds detected in at least one fish species from both ponds included metals (arsenic, chromium, copper, lead, mercury, nickel, selenium, and zinc) and pesticides (methoxychlor, p,p'-DDT, p,p'-DDD, and p,p'-DDE). Of the metals, only mercury and zinc were detected in all of the fish. Of the pesticides, only p,p'-DDD and p,p'-DDE were detected with the highest frequency in both ponds. The other chemicals were detected in less than 50 percent of the samples with the exception of selenium and nickel in yellow perch. Antimony was detected in only one sample, a bullhead from Puffer Pond. Endosulfan sulfate was detected in one sample of yellow perch collected from Ministers Pond.

4.2.3 Background Screening

Analytical results for the fish collected from Ministers Pond were compared to regional or national reference levels, as shown in Table 4-5. These comparisons indicate that metals and pesticides in fish from Ministers Pond are generally lower than levels in fish from other background locations in Massachusetts and nationally. Few exceedances of reference levels were found, and the magnitude of these exceedances was generally less than twice the reference level.

As for Puffer Pond, similar conclusions can be drawn, in that few chemicals showed a consistent pattern of elevation in comparison to regional or national reference levels, or to levels of chemicals in Ministers Pond. A few marginally elevated concentrations of methoxychlor, lead, and zinc were found, particularly in yellow perch.

4.2.4 Statistical Comparisons

Preliminary screening and comparison of chemicals in fish from Puffer Pond and Ministers Pond (Table 4-5 and 4-6) indicated that mercury, zinc, p,p'-DDD, and p,p'-DDE had consistently high detection frequencies in fish from both ponds. Therefore, the concentrations of these four chemicals in Puffer Pond were evaluated based on levels of the same chemicals detected in corresponding fish species from Ministers Pond. In each case, the data sets were compared using the t-test because visual observation of the data showed that the chemical concentrations were normally distributed and that a parametric test was, therefore, appropriate. In addition, prior to performing statistical comparisons, the concentrations of p,p'-DDD in pickerel from Ministers Pond and the concentrations of p,p'-DDD in bullhead from Ministers Pond, were Winsorized (Section 3.3) to account for the one value below the detection limit that each data set contained. Tables 4-7 through 4-10 summarize the results of the t-tests.

Table 4-5

SUMMARY OF ANALYTICAL RESULTS FOR MINISTERS POND (µg/g)

Analyte	Detection Frequency	Range		Regional or National Background	Frequency Above Background[e]
		Minimum	Maximum		
PICKEREL (n = 8)					
Antimony	0/8	<0.048	<0.050	NA	NA
Arsenic	1/8	<0.096	0.105	0.23[b]	0
Chromium	4/8	<0.096	0.882	0.5[a]	1/8
Copper	2/8	<0.478	2.23	2.2[a]	1/8
Lead	0/8	<0.048	<0.050	0.03[a]	N/A
Mercury	8/8	0.414	0.79	1.1[a]	0/8
Nickel	2/8	<0.096	0.164	1.6[a]	1/8
Selenium	1/8	<0.191	0.223	0.71[b]	0/8
Zinc	8/8	5.25	9.19	9.4[a]	0/8
Endosulfan Sulfate	0/8	<0.001	<0.001	NA	NA
Methoxychlor	1/8	<0.013	0.021	0.00132[c]	1/1
P,P-DDD	7/8	<0.001	0.004	0.06[d]	0/8
P,P-DDE	8/8	0.002	0.007	0.19[d]	0/8
P,P-DDT	0/8	<0.001	<0.001	0.03[d]	0/8
PERCH (n = 7)					
Antimony	0/7	<0.047	<0.196	NA	NA
Arsenic	0/7	<0.095	<0.392	0.23[b]	0/6
Chromium	1/7	<0.095	1.56	0.7[a]	1/7
Copper	2/7	<0.474	12.2	6[a]	1/7
Lead	2/7	<0.47	0.083	0.1[a]	0/7
Mercury	7/7	0.133	0.41	0.77[a]	0/7
Nickel	1/7	<0.095	0.099	0.3[a]	0/6
Selenium	6/7	0.281	0.369	0.71[b]	0/6
Zinc	7/7	4.02	14.7	6.1[a]	2/7
Endosulfan Sulfate	1/7	<0.001	0.002	NA	NA
Methoxychlor	3/7	<0.013	0.053	0.00132[c]	3/3
P,P-DDD	7/7	0.003	0.009	0.06[d]	0/7
P,P-DDE	7/7	0.005	0.022	0.19[d]	0/7
P,P-DDT	2/7	<0.001	0.002	0.03[d]	0/7

Table 4-5

SUMMARY OF ANALYTICAL RESULTS FOR MINISTERS POND (µg/g)

Analyte	Detection Frequency	Range		Regional or National Background	Frequency Above Background[e]
		Minimum	Maximum		
BULLHEAD (n = 4)					
Antimony	0/4	<0.049	<0.050	NA	NA
Arsenic	0/4	<0.097	<0.099	0.23[b]	0/4
Chromium	1/4	<0.097	0.431	NA	NA
Copper	0/4	<0.485	<0.497	1.14[b]	0/4
Lead	1/4	<0.049	0.051	0.32[b]	0/4
Mercury	4/4	0.096	0.89	0.34[c]	1/4
Nickel	0/4	<0.097	<0.099	NA	NA
Selenium	2/4	<0.194	0.230	0.71[b]	0/4
Zinc	4/4	3.63	7.52	46.26[b]	0/4
Endosulfan Sulfate	0/4	<0.001	<0.001	NA	NA
Methoxychlor	0/4	<0.013	<0.013	0.00132[c]	0/4
P,P-DDD	3/4	<0.001	0.013	0.06[d]	0/4
P,P-DDE	4/4	0.002	0.021	0.19[d]	0/4
P,P-DDT	0/4	<0.001	<0.001	0.03[d]	0/4

[a] Data compiled from MDEP. Values shown are the maximum concentrations reported from the clean reference waterbodies in central Massachusetts.
[b] Lowe *et al.* 1985. Values are the 85th percentile of nationwide fish data.
[c] USEPA 1992a. Value shown is the mean concentration of nationwide fish data.
[d] Schmitt *et al.* 1990. Values shown are the geometric mean concentrations of nationwide fish data (1984 collection period).
[e] If the detection limit for a given sample was higher than the background value, this sample was not used in the comparison.

NA - Not available.
N/A - Not applicable.

Source: Ecology and Environment, Inc. 1994.

Table 4-6

SUMMARY OF ANALYTICAL RESULTS FOR PUFFER POND (μg/g)

Analyte	Detection Frequency	Range		Regional or National Background	Frequency Above Background[e]	Ministers Pond	Frequency Above Ministers Pond
		Mini-mum	Maxi-mum				
PICKEREL (n = 8)							
Antimony	0/8	<0.045	<0.051	NA	NA	<0.050	N/A
Arsenic	2/8	<0.091	0.105	0.23[b]	0/8	0.105	0/8
Chromium	0/8	<0.091	<0.101	0.5	0/8	0.882	0/8
Copper	2/8	<0.454	0.770	2.2	0/8	2.23	0/8
Lead	2/8	<0.045	0.585	0.03	2/8	<0.050	2/8
Mercury	8/8	0.353	0.873	1.1	0/8	0.79	1/8
Nickel	1/8	<0.091	0.120	1.6	0/8	0.164	0/8
Selenium	4/8	<0.187	0.290	0.71[b]	0/8	0.223	2/8
Zinc	8/8	4.69	7.05	9.4	0/8	9.19	0/8
Endosulfan Sulfate	0/8	<0.001	<0.001	NA	0/8	<0.001	N/A
Methoxychlor	2/8	0.035	0.061	0.00132[c]	2/2	0.021	2/8
P,P-DDD	8/8	0.002	0.024	0.06[d]	0/8	0.004	6/8
P,P-DDE	8/8	0.002	0.030	0.19[d]	0/8	0.007	6/8
P,P-DDT	0/8	<0.001	<0.001	0.03[d]	0/8	<0.001	N/A
PERCH (n = 8*)							
Antimony	0/7	<0.044	<0.053	NA	NA	<0.196	N/A
Arsenic	1/7	<0.089	0.098	0.23[b]	0/5	<0.392	N/A
Chromium	3/7	<0.096	0.306	0.7	0/7	1.56	0/7
Copper	3/7	<0.481	13.8	6	1/7	12.2	1/7
Lead	7/7	0.055	0.162	0.1	3/7	0.083	3/7
Mercury	7/7	0.149	1.12	0.77	1/7	0.41	2/7
Nickel	5/7	<0.099	0.329	0.3	1/7	0.099	5/7
Selenium	7/7	0.254	0.417	0.71[b]	0/7	0.39	2/7
Zinc	7/7	5.01	7.74	6.1	4/7	14.7	0/7
Endosulfan Sulfate	0/8	<0.001	<0.001	NA	NA	0.002	N/A
Methoxychlor	5/7	<0.013	0.030	0.00132[c]	4/4	0.053	0/8
P,P-DDD	8/8	0.020	0.050	0.06[d]	0/7	0.009	8/8
P,P-DDE	8/8	0.040	0.100	0.19[d]	0/7	0.022	8/8
P,P-DDT	2/8	<0.001	0.005	0.03[d]	0/7	0.022	0/8

Table 4-6

SUMMARY OF ANALYTICAL RESULTS FOR PUFFER POND (μg/g)

Analyte	Detection Frequency	Range		Regional or National Background	Frequency Above Background[e]	Ministers Pond	Frequency Above Ministers Pond
		Mini-mum	Maxi-mum				
BULLHEAD (n = 8)							
Antimony	1/8	<0.048	0.082	NA	NA	<0.050	0/0
Arsenic	0/8	<0.096	<0.100	0.23[b]	0/8	<0.099	N/A
Chromium	1/8	<0.096	5.05	NA	NA	0.431	1/8
Copper	2/8	<0.481	5.16	1.4[b]	1/8	<0.497	2/8
Lead	3/8	<0.048	0.245	0.32[b]	0/8	0.051	3/8
Mercury	8/8	0.096	0.099	0.34[c]	0/8	0.89	0/8
Nickel	0/8	<0.096	<0.100	NA	NA	<0.099	N/A
Selenium	0/8	<0.191	<0.199	0.71[b]	0/8	0.230	N/A
Zinc	8/8	3.47	6.37	46.26[b]	0/8	7.52	0/8
Endosulfan Sulfate	0/8	<0.001	<0.001	NA	NA	<0.001	N/A
Methoxychlor	1/8	<0.013	<0.031	0.00132[c]	1/1	<0.013	1/8
P,P-DDD	8/8	0.014	0.080	0.06[d]	1/8	0.013	8/8
P,P-DDE	8/8	0.023	0.080	0.19[d]	0/8	0.021	8/8
P,P-DDT	0/8	<0.001	<0.001	0.03[d]	0/8	<0.001	N/A

[a] Data compiled from MDEP. Values shown are the maximum concentrations reported from clean reference waterbodies in central Massachusetts.
[b] Lowe *et al.* 1985. Values are the 85th percentile of nationwide fish data.
[c] USEPA 1992. Value shown is the mean concentration of nationwide fish data.
[d] Schmitt *et al.* 1990. Values shown are the geometric mean concentrations of nationwide fish data (1984 collection period).
[e] If the detection limit for a given sample was higher than the background value, this sample was not used in the comparison.

NA - Not available.
N/A - Not applicable.

* Although eight fish were submitted for analysis, metals analyses were only performed on seven fish. Hence the effective sample number for metals is n = 7, for pesticides it is n = 8.

Source: Ecology and Environment, Inc. 1994.

Table 4-7

COMPARISON OF MERCURY CONCENTRATIONS OF SAMPLED FISH (μg/g)

Parameters	Locations	Species		
		Pickerel	Bullhead	Perch
Sample Numbers	Puffer Pond	8	8	8
	Ministers Pond	8	4	7
Mean	Puffer Pond	0.613	0.0975	0.377
	Ministers Pond	0.500	0.3235	0.245
Standard Deviation	Puffer Pond	0.1660	0.0009	0.3513
	Ministers Pond	0.1230	0.3814	0.1058
Coefficient of Variation	Puffer Pond	28%	1%	97%
	Ministers Pond	25%	125%	45%
P (t-test, one-tailed analysis)		0.0738	NC	0.1867

Source: Ecology and Environment, Inc. 1994.

Key:

NC = Not calculated.

Table 4-8

COMPARISON OF ZINC CONCENTRATIONS OF SAMPLED FISH
(μg/g)

Parameters	Locations	Species		
		Pickerel	Bullhead	Perch
Sample Numbers	Puffer Pond	8	8	7
	Ministers Pond	8	4	7
Mean	Puffer Pond	5.485	4.290	6.449
	Ministers Pond	7.134	5.075	6.251
Standard Deviation	Puffer Pond	0.8613	0.9846	0.9488
	Ministers Pond	1.6377	1.6902	3.825
Coefficient of Variation	Puffer Pond	16%	24%	15%
	Ministers Pond	24%	35%	63%
P (t-test, one-tailed analysis)		NC	NC	0.449

Source: Ecology and Environment, Inc. 1994.

Key:

NC = Not calculated.

Table 4-9

COMPARISON OF p,p'-DDD CONCENTRATIONS OF SAMPLED FISH (μg/g)

Parameters	Locations	Species		
		Pickerel	Bullhead	Perch
Sample Number	Puffer Pond	8	8	8
	Ministers Pond	8	4	7
Mean	Puffer Pond	0.012	0.0326	0.03737
	Ministers Pond	0.0025[a]	0.009[a]	0.006
Standard Deviation	Puffer Pond	0.0064	0.0216	0.0102
	Ministers Pond	0.0006[a]	0.0052[a]	0.0021
Coefficient of Variation	Puffer Pond	55%	68%	28%
	Ministers Pond	22%[a]	41%[a]	36%
P (t-test, one-tailed analysis)		0.00811[a]	0.0208[a]	0.0000139

[a]Values Winsorized to account for one measurement below the detection limit (see text).

Source: Ecology and Environment, Inc., 1994.

Table 4-10

COMPARISON OF p,p'-DDE CONCENTRATIONS OF SAMPLED FISH (μg/g)

Parameters	Locations	Species		
		Pickerel	Bullhead	Perch
Sample Numbers	Puffer Pond	8	8	8
	Ministers Pond	8	4	7
Mean	Puffer Pond	0.019	0.0461	0.0775
	Ministers Pond	0.004	0.00975	0.0107
Standard Deviation	Puffer Pond	0.0080	0.0192	0.0198
	Ministers Pond	0.0018	0.0084	0.0053
Coefficient of Variation	Puffer Pond	43%	43%	26%
	Ministers Pond	44%	91%	52%
P (t-test, one-tailed analysis)		0.000455	0.000524	0.00000816

Source: Ecology and Environment, Inc., 1994.

Mercury

Mean concentrations of mercury in pickerel and yellow perch were greater in Puffer Pond than Ministers Pond (Table 4-7). The mean value of mercury in pickerel from Puffer Pond is approximately 22 percent higher than the mean mercury level in pickerel from Ministers Pond, and the level of confidence that this difference is not due to chance is approximately 92 percent (i.e., 1 - P). For yellow perch, the difference between the mean values for mercury is even greater (approximately 54 percent higher in Puffer Pond), however, the data are also more variable and consequently the level of confidence that this difference is not due to chance is approximately 81 percent.

The statistical power of these comparisons is a function of sample size, the coefficient of variation (CV), and the magnitude of the difference between the two ponds. The power of a test is a measure of the probability of not accepting a false null hypothesis. For the comparison of mean mercury levels in pickerel and perch, a difference of less than 30 percent may be detected with a confidence level of 70 percent and power of 90 percent, given a sample size of $n=8$, and a CV of <30 percent (see Section 3). Hence, for pickerel the power of discriminating observed differences of less than 30 percent between the two ponds (with a confidence of 70 percent or greater) is within the performance standards established for this study. For the comparison of mean mercury levels in perch, however, given the yellow perch CVs of greater than 30 percent, the probability of detecting a difference of less than 30 percent with a confidence of 70 percent is less than 90 percent.

Mean concentrations of mercury in bullheads were greater in Ministers Pond than in Puffer Pond. Therefore, statistical comparisons of means for bullhead were not conducted, although clearly the results do not support the hypothesis of higher concentrations of mercury in fish from Puffer Pond.

Zinc

Mean concentrations of zinc were greater in Puffer Pond than Ministers Pond for yellow perch (Table 4-8). Given the small magnitude of the difference (approximately 3 percent) and the high variability of the results, there is a very low confidence (approximately 55 percent) that higher zinc levels in perch from Puffer Pond are not due to chance. Since the mean levels of zinc in pickerel and bullhead were higher in Ministers Pond than their corresponding concentrations in Puffer Pond, these means were not statistically compared.

Pesticides (p,p'-DDD and p,p'-DDE)

Mean concentrations of p,p'-DDD and p,p'-DDE were greater in Puffer Pond than Ministers Pond for all three target fish species (Tables 4-9 and 4-10). The results of the t-tests indicate that all of these differences are significant at the conventional significance level of P less than 0.05.

4.3 SURFACE WATER AND SEDIMENT SAMPLING RESULTS

Sampling results for Puffer Pond were evaluated using the same screening criteria used elsewhere at the Annex (E & E 1994). However, background levels were based on sampling results from Ministers Pond. Table 4-11 presents the water quality parameters as measured at each surface water and sediment location. The analytical results of surface water and sediment samples collected from Puffer Pond and Ministers Pond are presented in Appendix D.

Of concern at Puffer Pond were the arsenic and lead levels observed in both surface water and sediments. Arsenic (up to 2.83 micrograms per liter (μg/L)) was detected in all six surface water samples from Puffer Pond at levels exceeding the screening level of 0.018 μg/L (Massachusetts/Clean Water Act Water Quality Criteria (MA/CWA WQC) for consumption of water and fish). In contrast, arsenic was not detected at levels above the method detection limit in Ministers Pond surface water. The lead concentration in a single Puffer Pond surface water sample (3.25 μg/L) exceeded the highest level in the background pond (3.02 μg/L) and slightly exceeded the screening value of 3.2 μg/L (MA/CWA WQC for protection of aquatic life). Cadmium (3.06 μg/L) was detected in one Puffer Pond sample above the screening level of 1.1 μg/L (MA/CWA WQC for protection of aquatic life). No mercury was detected in either Puffer Pond or Ministers Pond surface water samples.

All six sediment samples taken from Puffer Pond contained arsenic concentrations above the screening value of 6 μg/g. In contrast, only one sediment sample from Ministers Pond had arsenic (9.56 μg/g) above the screening value. All results were below the NOAA effects-range median (ERM) value of 85 μg/g, but four samples from Puffer Pond exceeded the NOAA effects range low (ERL) value of 33 μg/g. Mercury was not detected in sediment samples from either Puffer Pond or Ministers Pond. For further information refer to the Phase II Site Investigation Report (E & E 1994).

Table 4-11

PUFFER AND MINISTERS POND WATER QUALITY PARAMETERS

Sample Number	pH	Temp. (°C)	Conductivity (μs)	Turbidity (NTUs)	Dissolved Oxygen (%)	Date	Water Depth (FT)
Puffer Pond Samples							
WXPUF011	6.85	7.2	0.064	13	10.16	11/05/93	5
WXPUF021	6.85	7.0	0.063	7	10.23	11/05/93	6.5
WXPUF031	6.77	6.9	0.063	4	10.13	11/05/93	5
WXPUF041	6.77	6.9	0.063	4	10.11	11/05/93	4.5
WXPUF051	6.76	6.9	0.063	4	10.04	11/05/93	5
WXPUF061	6.68	6.9	0.063	4	9.66	11/05/93	5.5
Ministers Pond Samples							
WXOFA011	6.61	5.9	0.174	4	6.29	11/09/93	4.5
WXOFA021	6.45	6.0	0.174	4	6.07	11/09/93	5.5
WXOFA031	6.56	5.3	0.174	4	6.07	11/09/93	5.5
WXOFA041	6.51	5.4	0.175	7	6.03	11/09/93	4.5
WXOFA051	6.54	5.8	0.176	4	4.92	11/09/93	5
WXOFA061	6.45	4.4	0.172	7	5.26	11/09/93	2.5

Source: Ecology and Environment, Inc. 1994.

5. CONCLUSIONS

In a previous investigation (USAEHA 1991), levels of mercury above the FDA action level were detected in one fish sample taken from Puffer Pond. A quantitative exposure and risk assessment (OHM 1994) determined that risks to fishermen from the consumption of Puffer Pond fish were negligible. However, several factors, including the small sample size and the absence of background samples for comparison purposes, limited the certainty of these conclusions. This study was conducted to complement the previous studies, to verify that site-related contaminants are present in the pond, and to compare the concentrations of these chemicals to corresponding chemical concentrations in fish from a reference pond believed to represent background conditions. The results show that mercury, p,p'-DDD, p,p'-DDE, and zinc were consistently present in fish tissue from both ponds.

5.1 MERCURY

Because of its potential toxicological effects and occurrence above a regulatory guideline, mercury is of greatest concern. Mercury was present in 22 of 23 fish from Puffer Pond and 17 of 19 fish from Ministers Pond, and was detected in excess of the 1.0 μg/g FDA action level, at a concentration of 1.12 μg/g in one fish. This sample was analyzed as a whole body sample and is therefore not as relevant to determining human health risk as the analysis of a filet (a more common preparation for human consumption). However, this result is very pertinent to the study of ecological risk and exposure, since whole fish are a primary source for piscivorous wildlife.

The mean concentration of mercury in pickerel was 22 percent higher in Puffer Pond than it was in Ministers Pond. This result is statistically significant based on the standards of performance set for the purpose of this study (Section 4). Mercury was also higher on average in perch. In bullhead, however, mercury was more elevated in fish from Ministers Pond.

While the results of this study demonstrate that mercury is present in fish from both Puffer Pond and Minister's Pond, mercury was not detected in any of the surface water or sediment samples above the method detection limits of 0.2 μg/L and 0.1 mg/kg, respectively. This indicates that mercury in low concentrations in surface water or sediment of these two ponds bioaccumulates to detectable concentrations in fish.

These findings are consistent with studies conducted in Canada, Scandinavia, and in the northcentral and northeastern U.S., where appreciable mercury concentrations in fish are associated with low pH of lake waters. Lake surveys conducted over the past decade have demonstrated elevated levels of mercury in fish from hundreds of lakes in remote areas lacking known sources of mercury. Widespread acidic deposition in poorly buffered watersheds is thought to be largely responsible for the observed trend (Wiener and Stokes 1990). Research has shown that the increasing levels of mercury in remote ecosystems are

also related to increases in atmospheric deposition of mercury from global and regional anthropogenic sources, and that mercury burdens in undisturbed ecosystems increase with proximity to industrialized areas (Swain *et al.* 1992). As Puffer Pond and Ministers Pond are relatively acidic ponds in watersheds located within and just downwind of highly industrialized areas, both ponds possess the key characteristics associated with bioaccumulation of mercury in fish.

Although the mechanisms of bioaccumulation are not completely understood, the enhanced uptake of mercury in low-pH water appears to be related to greater production of bioavailable forms of mercury, such as methylmercury, under acidic conditions (Wiener and Stokes 1990). Methylmercury is accumulated from water by a factor of 3 million times in fish (Zillioux *et al.* 1993).

Table 5-1 provides some comparative values of mercury concentrations in fish from Massachusetts and other locations in the U.S. unaffected by point sources of mercury contamination. The data represent a variety of fish species, analytical methods, times and locations of capture, and other variables that make direct comparisons uncertain, but qualitatively the data show that it is not unusual for mercury concentrations in fish from uncontaminated waters to exceed 1 μg/g. The average concentrations in fish from the various studies range from 0.11 μg/g to 0.47 μg/g. It can be seen that the levels of mercury found in fish in Puffer Pond (maximum of 1.12 μg/g and average of 0.36 μg/g) and in Minister's Pond (maximum of 0.89 and average of 0.37 μg/g) are well within the range of concentrations reported for other clean water bodies.

5.2 PESTICIDES IN FISH

The results for pesticides clearly show that there are greater concentrations of DDT breakdown products in Puffer Pond fish than in Ministers Pond fish (Section 4). This result is not surprising; pesticides were commonly used on road sides and around buildings during the operation of the army facility. The presence of pesticides in the vicinity of Puffer Pond is discussed in detail in the Phase II Site Investigation report for the Sudbury Annex (E & E 1994). Drainage from surrounding areas into Puffer Pond may have caused an accumulation of p,p'-DDD and p,p'-DDE in exposed fish. However, it is very important to mention that the concentrations of pesticides in fish from Puffer Pond, despite being clearly more elevated than in Ministers Pond, are consistent with the generally low levels of pesticides found in fish nationwide (USEPA 1992a). Only one sample, a bullhead from Puffer Pond, barely exceeded the national p,p'-DDD background level of 0.06 ppm with a concentration of 0.08 ppm. Consequently, it is unlikely that Puffer Pond presents an unusual risk (if any) as a result of the pesticides in fish. Puffer Pond merely exhibits the low-level nationwide presence of pesticide contamination to a greater degree than Ministers Pond.

5.3 ZINC

Zinc was determined to be present in higher concentrations in pickerel and bullhead from Ministers Pond. In any case, zinc was not detected in concentrations that warrant concern, since all detected concentrations were below regional MDEP levels.

Table 5-1

MERCURY IN FISH
COMPARISON OF PUFFER POND AND MINISTERS POND TO MASSACHUSETTS AND NATIONAL DATA

Source	Locations	Sample Number	Detection Frequency	Range (ppm)	Avg (ppm)
EPA National Study of Chemical Residues in Fish (USEPA 1992)	Nationwide	374 sites	92.2%	ND - 1.77	0.26
	Nationwide background	21 sites	NA	ND - 1.77	0.34
National Contaminant Biomonitoring Program (Lowe *et al.* 1985)	Nationwide	112 sites	NA	0.01 - 1.10	0.11
MDEP Fish Tissue Data	Massachusetts "clean water reference"	47 fish	100.0%	0.04 - 1.3	0.47
USAEHA Study (USAEHA 1991)	Puffer Pond	1 fish	100.0%	1.2	-
1992 USAEC Study (OHM 1994)	Puffer Pond	12 fish	66.7%	ND - 0.32	NA
1993 USAEC Study (This report)	Puffer Pond	23 fish	100.0%	ND - 1.12	0.36
	Ministers Pond	19 fish	100.0%	0.096 - 0.89	0.37

Key:

ND = Below detection limit.
NA = Not available.

Source: Ecology and Environment, Inc. 1994.

5.4 DISCUSSION OF UNCERTAINTY

Several aspects of this study can introduce uncertainty to the conclusions previously described. These aspects, as described below, were taken into consideration when presenting the conclusions to this report. Limited sample size, the inherent sample variation, and finally the appropriateness of using Ministers Pond as a reference pond are all likely to have a introduced some degree of uncertainty into this study.

Prior to the initiation of the study, a sample size of seven fish was determined to be adequate and sufficient to detect a 10 percent to 30 percent difference between sample means with power of 90 percent to 95 percent and a confidence of 70 percent to 80 percent; a sample size of eight was targeted to allow a margin of error if the CV of samples exceeded 30 percent (E & E 1993). Except for bullhead in Ministers Pond, a sufficient sample size was obtained for most data sets. The reduced Ministers Pond sample size for bullhead decreases the power of the tests for comparing chemical concentrations in bullhead from both ponds. When the power of the test is decreased, the probability of drawing a false negative conclusion and deciding that there is no real difference between concentrations (when in actuality there is one) increases. Despite the decrease in power, results of t-tests that included bullhead were used to examine the general tendency of the sample means and should be considered in light of results of the other t-tests performed (pickerel and perch).

Inherent sample variation is another aspect of the data that can introduce uncertainty to statistical results since a greater degree of variation in the data reduces the power of a statistical test. In designing the sample size for this study a CV of 10 percent to 30 percent was assumed. Several sample sets exceeded a 30 percent CV and consequently reduced the power of the relevant t-tests. The CVs of individual sample sets used in statistical comparisons are listed in Tables 4-7 through 4-10 along with the remaining t-test statistics.

Finally, in light of the purpose of this study, it is important to discuss the appropriateness of using Ministers Pond as representative of background conditions. Careful attention was paid to the selection of Ministers Pond, and in the course of this study, results have shown that concentrations of chemicals detected in fish from Ministers Pond are consistent with regional and national "background" conditions (Table 5-1). In very few cases did an analytical result for fish from Ministers Pond exceed published regional or national levels for that chemical. Consequently, Ministers Pond appears to be representative of background conditions and the results of this study can be interpreted accordingly.

6. REFERENCES CITED AND CONSULTED

Ecology and Environment, Inc. (E & E), 1993, *Technical Plan Addenda, Phase II Site Inspections, Remedial Investigations, Fort Devens Sudbury Training Annex, Massachusetts*, prepared for Commander, U.S. Army Environmental Center, Aberdeen Proving Ground, Maryland.

E & E, 1994a, *Draft Master Environmental Plan, Fort Devens Sudbury Training Annex, Massachusetts*, prepared for Commander, U.S. Army Environmental Center, Aberdeen Proving Ground, Maryland.

E & E, 1994b, *Phase II Site Investigations Report, Fort Devens Sudbury Training Annex, Massachusetts*, prepared for Commander, U.S. Army Environmental Center, Aberdeen Proving Ground, Maryland.

Gilbert, R.O., 1987, *Statistical Methods for Environmental Pollution Monitoring*, Van Nostrand Reinhold Company, New York.

Lowe, T.P., T.W. May, W.G. Brumbaugh, and D.A. Kane, 1985, "National Contaminant Biomonitoring Program: Concentrations of Seven Elements in Freshwater Fish, 1971-1981," *Archives of Environmental Contamination and Toxicology*, U.S. Fish and Wildlife Service, Columbia National Fisheries Research Laboratory, Columbia, Missouri.

Massachusetts Department of Environmental Protection (MDEP), 1992a, letter from D. Lynn Chapell, section chief, to Carol J. Howard, Department of the Army, re: Reference data for Plow Shop Pond, Cold Spring Brook, and Puffer Pond.

MDEP, 1992b, letter from D. Lynn Chapell, section chief, to Ronald Ostrowski, Department of the Army, re: comments to Puffer Pond Study.

OHM Remediation Services Corporation (OHM), 1994, *Puffer Pond Fish Study, Fort Devens Sudbury Training Annex, Sudbury, Massachusetts,* prepared for U.S. Army Environmental Center, Aberdeen Proving Ground, Maryland.

Sokal, R.R., and F.J. Rohlf, 1981, *Biometry, 2nd Edition*, W.H. Freeman and Company, New York, New York.

Schmitt, C.J., Zajicek, J.L., and P.H. Peterman, 1990. National Contaminant Biomonitoring Program: Residues of Organochlorine Chemicals in U.S. Freshwater Fish, 1976-1984. Arch. Environ. Contam. Toxicol. 19: 748-781.

Swain, E.B., Engstrom, D.R., Brigham, M.E., Henning, T.A., and P.L. Brezonik, 1992. Increasing rates of atmospheric mercury deposition in midcontinental North America. *Science* 257:784-787.

United States Army Environmental Hygiene Agency (USAEHA), 1991, *Environmental Sampling of Puffer Pond, Sudbury-Annex, Fort Devens, Massachusetts*, Receiving Water Biological Study No. 32-24H606-91, Aberdeen Proving Ground, Maryland.

United States Department of the Army, Stratford H. Kay Environmental Laboratory, *Long-Term Effects of Dredging Operations Program, Technical Report No. D-84-7, Potential for Biomagnification of Contaminants Within Marine and Freshwater Food Webs*.

United States Environmental Protection Agency (USEPA), 1992a, *National Study of Chemical Residues in Fish, Volume I.* Office of Science and Technology (WH-551), Washington, D.C., EPA 823-R-92-008a/b.

USEPA, 1992b, *Guidance for Data Useability in Risk Assessment (Part A)*, Final, Office of Emergency and Remedial Response, Washington, DC, Publication 9285.7-09A.

USEPA, 1989, *Ecological Assessment of Hazardous Waste Sites: A Field and Laboratory Reference.*

United States Geological Survey (USGS), 1988, *7.5 Minute Series (topographic) Quadrangle: Hudson, Massachusetts.*

USGS, 1987, *7.5 Minute Series (topographic) Quadrangle: Maynard, Massachusetts.*

Wiener, J.G. and P.M. Stokes, 1990. Enhanced bioaccumulation of mercury, cadmium and lead in low-alkalinity waters: an emerging regional environmental problem. *Environ. Toxicol. Chem.* 9:821-823.

Zillioux, E.J., Porcella, D.B., and J.M. Benoit, 1993. Mercury cycling and effects in freshwater wetland ecosystems. *Environ. Toxicol. Chem.* 12:2245-2264.

APPENDIX A

MDEP FISH STUDY METHODS

THIS
PAGE
IS
MISSING
IN
ORIGINAL
DOCUMENT

3.5 FISH

3.5.1 DEFINITION: For the purpose of this standard operating procedure, fish shall include those vertebrate species belonging to the classes Agnatha (jawless fishes), Chondrichthyes (cartilaginous fishes), and Osteichthyes (bony fishes).

3.5.2 OBJECTIVES

1. To provide data for surface water quality standards evaluations and the National Pollutant Discharge Elimination System permit program;

2. to provide data to assess human health concerns with special to fish consumption; and

3. to provide complimentary data for assessing water quality impacts to aquatic and semi-aquatic biota.

3.5.3 FIELD SAMPLING

The collection of fish samples and field data pertaining to the objectives stated above are conducted in cooperation with the Massachusetts Division of Fisheries and Wildlife (MDFW). The MDFW supplies one full-time biologist and equipment when necessary. Fish are collected under guidelines included in a "Scientific Collecting Permit for Fish" issued to the Division of Water Pollution Control by the Division of Fisheries and Wildlife. This permit is renewed annually.

Physical Measurements

When assessing water quality impacts as stated in objective 3.5.2(3) data concerning stream reach length, width, and average depth are recorded. Substrate characteristics are visually inspected and noted. Water temperature is also recorded. Also under objective 3.5.2(3) all fish are identified, weighed, and measured. Scales or spines are sampled and used for aging. All fish are then released if they show minimal stress. Under objectives 3.5.2 (1) and (2), only targeted species of appropriate size are collected, identified, weighed, and measured. These fish are brought back to the laboratory for processing. In lakes and ponds, collection areas are marked on prepared maps, and amount of effort (time) is recorded. When electrofishing is performed conductivity is recorded along with voltage used and relative success.

Gill Netting

Gill nets are entanglement gear best described as vertical walls of netting. The typical net used by this Division is of an experimental design. The nets are 38 meters in length and two meters in depth stretched. They usually include a 1.27 cm polypropylene float line and a 23 kg lead line. The net itself is composed of five 7.6 meter monofilament panels. Mesh sizes are: 2.54 cm; 3.175 cm; 3.81 cm; 4.445 cm; and 5.08 cm.

Nets are usually set in at least 2.5 m of water and are marked by a buoy on each end. An additional buoy is attached near the center of the net in water less than 3.0 m in depth to warn boaters and/or fishermen of the obstruction. Gill nets are checked every two hours to minimize the number of unwanted fish collected. When an adequate sample size is not obtained during a typical one day set, occasionally large meshed gill nets are reset and left overnight.

Electrofishing

Electrofishing is a sampling technique in which an electric current, either alternating (a.c.) or direct (d.c.), is generated into the water to temporarily stun fish for subsequent capture. To meet sampling needs, two types of electrofishing are employed depending on the site specific situation. In areas with an adequate boat access and water deep enough for outboard motor use, an electroshock boat utilizing a gas operated generator is used. In smaller lotic situations with a bottom substrate and depth suitable for wading, a battery operated backpack electrofishing unit is applied. Using either method only those fish appropriate to the sampling scheme are netted and retained until an adequate sample size is obtained.

Trapping

Wooden cylindrical catfish traps are used to collect catfish and bullheads (Ictaluridae). These are baited, set in suitable locations, and periodically checked. The trap has an opening on one end with a cone-shaped entrance. The fish enter through the cone and cannot find the entrance once in the box end of the trap.

Field Processing

Fish are sampled using any combination of the previously mentioned techniques. Sampling is continued until sampling goals are met or until time becomes a constraining factor. All fish are kept intact and fresh in a cooler of ice and transported back to the TSB lab for further processing and preparation.

3.5.4 LABORATORY ANALYSIS

Processing

Fish collected for objectives 3.5.2 (1) and (2) are used for bioaccumulation data analysis which is incorporated into public health determinations or National Pollutant Discharge Elimination System permit reviews. Each fish is weighed whole. Length is measured from the tip of snout with mouth closed to the longest part of the caudal fin slightly compressed. This is expressed as total length.

Each fish is rinsed with deionized water and filleted. A clean, sharp fillet knife is run along each side of the backbone and then just to the outside of the rib cage. This removes a boneless fillet from each side

of the fish. The fillet is then placed, skin down, on the glass filleting surface. The knife is used to separate the flesh from the skin. Skin is discarded except when preparing trout (Salmonidae). Skin is left intact on trout because it is believed to be the most common preparation method used by fishermen. One fillet, depending on the study, is either wrapped individually, or composited with fillets from other fish of the same species and size. The opposite fillet is wrapped individually, tagged with a three or four letter code and number, and archived for future use. Samples for metals analysis are wrapped in plastic (e.g., Saran) wrap. Samples to be tested for PCB's, percent lipids, and organic scan are wrapped in household grade aluminum foil. Fillets to be analyzed for dioxin are wrapped in aluminum foil which has been rinsed with methanol and methylene chloride. The filleting surface and knife are rinsed thoroughly after each fish is filleted. Processed fish are kept frozen until they are transported to the analytical laboratory for analysis.

Fish are analyzed for metals and/or organics depending on the individual study being performed. All results are reported as mg/kg. Quality control and assurance data are recorded with each run of samples by the analytical laboratory.

Aging

All fish collected are aged by use of scales or spines. Scales are taken from various areas of a fish depending on the species being sampled. Scales are dried in scale envelopes. The impressions are made on butyrate slides, with a scale press. The impressions can then be read off a scale reader or microfilm reader. Pectoral spines are collected from Ictalurids. These spines are dried and cleaned of excess skins and flesh. They are soaked in Axion detergent, which helps loosen the skin and flesh which results in easier removal. Spines are cross-sectioned at the basal recess on a low speed diamond bladed saw. Cross-sections of .10-.20 mm. can then be read through a compound microscope. Ages are expressed as years^{+}, for example 1^{+}, 2^{+}, 3^{+}.

3.5.5 DATA MANAGEMENT

Reporting of Results

In most cases involving objectives 3.5.2 (1) and (2) results are put into tabular form and a technical memorandum is written detailing the nature of the study, methods used, and any applicable recommendations. The memorandum is distributed to interested parties including the Massachusetts Department of Public Health and the DEQE Office of Research and Standards.

Computer Files

All fish data are entered into one of 4 DBase3+ files. The files include station identification information (STAID), a record of samples (SAMPREC), the results of analyses for metals (FISHMET), and the results for organics (FISHORG). These files are linked in such a manner that data can be retrieved by species, waterbody, analyses type, concentration of contaminant, year, size, and other metrics. Data from these files are the beginning of a statewide data base.

APPENDIX B

FISH COLLECTION PERMIT

Commonwealth of Massachusetts

Division of Fisheries & Wildlife

Wayne F. MacCallum, *Director*

SCIENTIFIC COLLECTING PERMIT FOR FISH 1993

ECOLOGY AND ENVIRONMENT. INC.
GEORGE STREBEL
368 PLEASANT VIEW DRIVE
LANCASTER. NY 14086

PERMIT#: 120.93SCF
DATE: 05/17/93

SUBPERMITTEE(S): DENNIS ROSS. KEITH DAVIDSON. PAUL AZZOPARDI. CARL MACH. ROBIN KIM. STEVE PETERSON. CHARLES EICH. JOHN HERMAN.

is (are) hereby authorized, in accordance with the provisions of Section 4, Chapter 131 of the Massachusetts General Laws, to remove from the wild within the Commonwealth, subject to conditions set forth below, the following species and numbers:

MAY COLLECT UP TO 60 FISH CONSISTING OF 10 PREDATORY FISH (LARGEMOUTH BLACK BASS. CHAIN PICKEREL). 10 INTERMEDIATE FEEDERS (SUNFISH. YELLOW PERCH) AND 10 BOTTOM FEEDERS (BULLHEADS) FROM FORT DEVENS SUDBURY ANNEX AND MINISTER'S POND. MAYNARD TO CHEMICALLY ANALYZE FOR HUMAN HEALTH AND ECOLOGICAL ASSESSMENT STUDY.

The following method(s) of taking is (are) hereby authorized:

GILL NETS. ELECTROSHOCKING GEAR

Collection activities under this permit shall be restricted to the following locations, subject to the approval of private landowners:

FORT DEVENS SUDBURY ANNEX AND MINISTER'S POND. MAYNARD

All specimens secured under this permit shall be donated to the following institution:

RETAINED FOR ANALYSIS

No specimens taken under authority of this permit may be sold. No specimens may be transferred to another not duly licensed.

This permit or a copy thereof shall be carried at all times by the permittee and ant subpermittee(s) while engaged in the activities authorized herein.

This permit does not absolve the permittee from compliance in full with any and all other applicable federal, state, and local requirements, including the acquisition of a federal endangered species permit if required.

Upon expiration of this permit, a complete report detailing all collection activities shall be filed with this office and must include a listing of all species taken, numbers of specimens, and the disposition of same.

This permit, unless sooner revoked for cause, shall expire on December 31 of the year of issue.

Wayne F. MacCallum

Wayne F. MacCallum, Director

Division of Fisheries & Wildlife
Leverett Saltonstall Building,
Government Center, 100 Cambridge Street, Boston, MA 02202 (617) 727-3151
An Agency of the Department of Fisheries, Wildlife & Environmental Law Enforcement

APPENDIX C

ANALYTICAL DATA
FISH SAMPLES

The following tables present the results of chemical analyses of the fish samples collected from Puffer Pond and Ministers Pond. The analyses were performed by Environmental Science and Engineering Laboratories. The tables are followed by copies of the chain-of-custody forms maintained to ensure sample integrity from sample collection to analysis.

File Type: CAT
Site Type: BIOL

Chemical Summary Report For
Sudbury Fish Samples
Units: UGG

	Site ID	E3-BCK-F01	E3-BCK-F02	E3-BCK-F03	E3-BCK-F04	E3-BCK-F05	E3-BCK-F06
	Field Sample ID	FXBCK011	FXBCK021	FXBCK031	FXBCK041	FXBCK051	FXBCK061
	Sample Date	11/09/93	11/07/93	11/07/93	11/07/93	11/07/93	11/09/93
Test	Parameter .						
TAL METAL	Antimony	< 0.049	< 0.048	< 0.050	< 0.049	< 0.050	< 0.048
	Arsenic	0.105	< 0.096	< 0.100	< 0.099	< 0.099	< 0.096
	Chromium	0.252	< 0.096	< 0.100	0.167	0.099	0.882
	Copper	2.23	< 0.478	< 0.498	< 0.494	< 0.495	0.700
	Lead	< 0.049	< 0.048	< 0.050	< 0.049	< 0.050	< 0.048
	Mercury	0.510 J	0.426 J	0.497 J	0.414 J	0.449 J	0.494 J
	Nickel	0.164	< 0.096	< 0.100	0.119	< 0.099	< 0.096
	Selenium	< 0.197	< 0.191	< 0.199	< 0.197	< 0.198	0.223
	Zinc	5.37	7.87	5.36	9.19	5.25	6.89
TCL Pest	Endosulfan Sulfate	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
	Methoxychlor	< 0.013	0.021	< 0.013	< 0.013	< 0.013	< 0.013
	P,P-DDD	0.002	0.003	0.004	0.003	0.002	0.002
	P,P-DDE	0.002	0.006	0.006	0.007	0.003	0.003
	P,P-DDT	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001

Source: USAEC IRDMIS Level 3/E & E, 1994.

Key:

< = below sample detection limit J = estimated U = unconfirmed on second column

File Type: CAT
Site Type: BIOL

Chemical Summary Report For
Sudbury Fish Samples
Units: UGG

Part 2 of 8

	Site ID	E3-BCK-F07	E3-BCK-F08	E3-BCK-F09	E3-BCK-F10	E3-BCK-F11	E3-BCK-F12
	Field Sample ID	FXBCK071	FXBCK081	FXBCK091	FXBCK101	FXBCK111	FXBCK121
	Sample Date	11/07/93	11/07/93	11/07/93	11/07/93	11/07/93	11/07/93
Test	Parameter .						
TAL METAL	Antimony	< 0.049	< 0.050	< 0.050	< 0.049	< 0.049	< 0.049
	Arsenic	< 0.097	< 0.099	< 0.099	< 0.099	< 0.097	< 0.098
	Chromium	< 0.097	< 0.099	< 0.099	< 0.099	< 0.097	0.431
	Copper	< 0.485	< 0.496	< 0.497	< 0.494	< 0.485	< 0.491
	Lead	< 0.049	< 0.050	0.051	< 0.049	< 0.049	< 0.049
	Mercury	0.790 J	0.421 J	0.890 J	0.210 J	< 0.098 UJ	< 0.096 UJ
	Nickel	< 0.097	< 0.099	< 0.099	< 0.099	< 0.097	< 0.098
	Selenium	< 0.194	< 0.198	0.230	0.202	< 0.194	< 0.196
	Zinc	8.49	8.65	4.62	7.52	4.53	3.63
TCL Pest	Endosulfan Sulfate	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
	Methoxychlor	< 0.013	< 0.013	< 0.013	< 0.013	< 0.013	< 0.013
	P,P-DDD	< 0.001	< 0.003	< 0.001	0.012	0.013	0.006
	P,P-DDE	0.003	< 0.005	0.002	0.021	0.011	0.005
	P,P-DDT	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001

Source: USAEC IRDMIS Level 3/E & E, 1994.

Key:

< = below sample detection limit J = estimated U = unconfirmed on second column

File Type: CAT
Site Type: BIOL

Chemical Summary Report For
Sudbury Fish Samples
Units: UGG

Part 3 of 8

	Site ID	E3-BCK-F13	E3-BCK-F14	E3-BCK-F15	E3-BCK-F16	E3-BCK-F17	E3-BCK-F18
	Field Sample ID	FXBCK131	FXBCK141	FXBCK151	FXBCK161	FXBCK171	FXBCK181
	Sample Date	11/07/93	11/07/93	11/07/93	11/07/93	11/09/93	11/09/93
Test	Parameter .						
TAL METAL	Antimony	< 0.049	< 0.049	< 0.196	< 0.048	< 0.047	< 0.049
	Arsenic	< 0.097	< 0.098	< 0.392	< 0.097	< 0.095	< 0.099
	Chromium	< 0.097	< 0.098	1.56	< 0.097	< 0.095	< 0.099
	Copper	< 0.485	< 0.489	12.2	< 0.483	< 0.474	< 0.493
	Lead	< 0.049	< 0.049	< 0.196	0.083	< 0.047	0.067
	Mercury	0.319 J	0.145 J	0.193 J	0.323 J	0.192 J	0.133 J
	Nickel	0.099	< 0.098	< 0.392	< 0.097	< 0.095	< 0.099
	Selenium	0.297	0.349	< 0.784	0.281	0.369	0.302
	Zinc	6.65	4.41	14.7	4.02	5.11	4.41
TCL Pest	Endosulfan Sulfate	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
	Methoxychlor	< 0.013	< 0.013	0.016	0.017	< 0.013	0.053
	P,P-DDD	0.007	0.005	0.005	0.003	0.009	0.005
	P,P-DDE	0.011	0.009	0.010	0.005	0.022	0.010
	P,P-DDT	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.002

Source: USAEC IRDMIS Level 3/E & E, 1994.

Key:

< = below sample detection limit J = estimated U = unconfirmed on second column

File Type: CAT
Site Type: BIOL

Chemical Summary Report For
Sudbury Fish Samples
Units: UGG

Part 4 of 8

	Site ID	E3-BCK-F19	E3-PUF-F01	E3-PUF-F02	E3-PUF-F03	E3-PUF-F04	E3-PUF-F05
	Field Sample ID	FXBCK191	FXPUF011	FXPUF021	FXPUF031	FXPUF041	FXPUF051
	Sample Date	11/09/93	11/02/93	11/02/93	11/02/93	11/02/93	11/02/93
Test	Parameter .						
TAL METAL	Antimony	< 0.052	< 0.049	< 0.045	< 0.050	< 0.050	< 0.050
	Arsenic	< 0.103	< 0.098	< 0.091	0.105	< 0.100	0.103
	Chromium	< 0.103	< 0.098	< 0.091	< 0.101	< 0.100	< 0.100
	Copper	2.50	0.777	< 0.454	< 0.504	< 0.502	< 0.499
	Lead	< 0.052	< 0.049	< 0.045	< 0.050	0.585	< 0.050
	Mercury	0.411 J	0.757 J	0.463 J	0.658 J	0.353 J	0.688 J
	Nickel	< 0.103	< 0.098	< 0.091	0.120	< 0.100	< 0.100
	Selenium	0.288	0.198	0.290	< 0.202	0.247	< 0.200
	Zinc	4.46	7.05	5.06	5.90	5.09	4.79
TCL Pest	Endosulfan Sulfate	0.002	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
	Methoxychlor	< 0.013	< 0.013	< 0.013	0.035	< 0.013	< 0.013
	P,P-DDD	0.008	0.002	0.024	0.008	0.011	0.009
	P,P-DDE	0.008	0.002	0.030	0.016	0.021	0.022
	P,P-DDT	0.002	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001

Source: USAEC IRDMIS Level 3/E & E, 1994.

Key:

< = below sample detection limit J = estimated U = unconfirmed on second column

File Type: CAT
Site Type: BIOL

Chemical Summary Report For
Sudbury Fish Samples
Units: UGG

Part 5 of 8

	Site ID	E3-PUF-F06	E3-PUF-F07	E3-PUF-F08	E3-PUF-F09	E3-PUF-F10	E3-PUF-F11
	Field Sample ID	FXPUF061	FXPUF071	FXPUF081	FXPUF091	FXPUF101	FXPUF111
	Sample Date	11/03/93	11/03/93	11/03/93	11/03/93	11/03/93	11/03/93
Test	Parameter .						
TAL METAL	Antimony	< 0.051	< 0.047	< 0.047	< 0.048	< 0.048	< 0.049
	Arsenic	< 0.101	< 0.094	< 0.094	< 0.096	< 0.096	< 0.099
	Chromium	< 0.101	< 0.094	< 0.094	< 0.096	< 0.096	< 0.099
	Copper	0.770	< 0.469	< 0.469	0.609	< 0.481	< 0.493
	Lead	0.081	< 0.047	< 0.047	< 0.048	< 0.048	< 0.049
	Mercury	0.873 J	0.560 J	0.549 J	< 0.098 UJ	< 0.097 UJ	0.098 J
	Nickel	< 0.101	< 0.094	< 0.094	< 0.096	< 0.096	< 0.099
	Selenium	< 0.202	0.192	< 0.187	< 0.191	< 0.193	< 0.197
	Zinc	6.38	4.69	4.92	3.65	4.11	3.47
TCL Pest	Endosulfan Sulfate	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
	Methoxychlor	< 0.013	0.061	< 0.013	< 0.013	< 0.013	< 0.013
	P,P-DDD	0.012	0.016	0.014	0.040	0.080	0.040
	P,P-DDE	0.020	0.020	0.023	0.060	0.080	0.040
	P,P-DDT	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001

Source: USAEC IRDMIS Level 3/E & E, 1994.

Key:

< = below sample detection limit J = estimated U = unconfirmed on second column

File Type: CAT
Site Type: BIOL

Chemical Summary Report For
Sudbury Fish Samples
Units: UGG

Part 6 of 8

	Site ID	E3-PUF-F12	E3-PUF-F13	E3-PUF-F14	E3-PUF-F15	E3-PUF-F16	E3-PUF-F17
	Field Sample ID	FXPUF121	FXPUF131	FXPUF141	FXPUF151	FXPUF161	FXPUF171
	Sample Date	11/03/93	11/03/93	11/03/93	11/03/93	11/03/93	11/02/93
Test	Parameter .						
TAL METAL	Antimony	< 0.050	0.082	< 0.049	< 0.050	< 0.05	< 0.050
	Arsenic	< 0.099	< 0.097	< 0.098	< 0.099	< 0.100	< 0.099
	Chromium	< 0.099	< 0.097	< 0.098	< 0.099	5.05	< 0.099
	Copper	< 0.496	< 0.486	< 0.491	< 0.497	5.16	< 0.498
	Lead	< 0.050	0.120	0.075	< 0.050	0.245	0.055
	Mercury	< 0.096 UJ	< 0.097 UJ	< 0.099 UJ	< 0.097 UJ	< 0.098 UJ	0.330 J
	Nickel	< 0.099	< 0.097	< 0.098	< 0.099	< 0.100	< 0.099
	Selenium	< 0.198	< 0.194	< 0.196	< 0.199	< 0.199	0.254
	Zinc	4.11	3.58	6.37	3.92	5.11	5.01
TCL Pest	Endosulfan Sulfate	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
	Methoxychlor	< 0.013	< 0.013	< 0.013	< 0.013	0.031	0.027
	P,P-DDD	0.030	0.014	0.020	0.017	0.020	0.020
	P,P-DDE	0.060	0.023	0.040	0.026	0.040	0.040
	P,P-DDT	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001

Source: USAEC IRDMIS Level 3/E & E, 1994.

Key:

< = below sample detection limit J = estimated U = unconfirmed on second column

File Type: CAT
Site Type: BIOL

Chemical Summary Report For
Sudbury Fish Samples
Units: UGG

Part 7 of 8

	Site ID	E3-PUF-F18	E3-PUF-F19	E3-PUF-F20	E3-PUF-F21	E3-PUF-F22	E3-PUF-F23
	Field Sample ID	FXPUF181	FXPUF191	FXPUF201	FXPUF211	FXPUF221	FXPUF231
	Sample Date	11/02/93	11/03/93	11/03/93	11/03/93	11/03/93	11/03/93
Test	Parameter .						
TAL METAL	Antimony	< 0.048	< 0.049	< 0.050	< 0.048	NA	< 0.053
	Arsenic	< 0.097	0.098	< 0.100	< 0.096	NA	< 0.105
	Chromium	0.185	< 0.098	0.306	< 0.096	NA	< 0.105
	Copper	< 0.483	< 0.488	13.8	< 0.481	NA	0.857
	Lead	0.072	0.121	0.062	0.162	NA	0.074
	Mercury	0.480 J	0.193 J	0.270 J	1.12 J	NA	0.149 J
	Nickel	0.329	0.159	< 0.100	0.110	NA	0.125
	Selenium	0.330	0.255	0.328	0.324	NA	0.417
	Zinc	7.29	5.82	7.74	5.94	NA	6.99
TCL Pest	Endosulfan Sulfate	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
	Methoxychlor	< 0.013	< 0.013	0.023	0.026	0.021	< 0.013
	P,P-DDD	0.040	0.050	0.040	0.040	0.024	0.045
	P,P-DDE	0.060	0.100	0.080	0.080	0.080	0.100
	P,P-DDT	< 0.001	0.005	< 0.001	0.004	< 0.001	< 0.001

Source: USAEC IRDMIS Level 3/E & E, 1994.

Key:

< = below sample detection limit J = estimated U = unconfirmed on second column

NA = Analysis not performed.

File Type: CAT
Site Type: BIOL

Chemical Summary Report For
Sudbury Fish Samples
Units: UGG

Part 8 of 8

	Site ID	E3-PUF-F24					
	Field Sample ID	FXPUF241					
	Sample Date	11/03/93					
Test	Parameter .						
TAL METAL	Antimony	< 0.044					
	Arsenic	< 0.089					
	Chromium	0.249					
	Copper	2.54					
	Lead	0.119					
	Mercury	< 0.097 UJ					
	Nickel	0.153					
	Selenium	0.377					
	Zinc	6.35					
TCL Pest	Endosulfan Sulfate	< 0.001					
	Methoxychlor	0.030					
	P,P-DDD	0.040					
	P,P-DDE	0.080					
	P,P-DDT	< 0.001					

Source: USAEC IRDMIS Level 3/E & E, 1994.

Key:

< = below sample detection limit J = estimated U = unconfirmed on second column

PROJECT NUMBER 3924065G 0200 PROJECT NAME E & E - FT. DEVENS
FIELD GROUP DV1BAT PROJECT MANAGER J.J. VONDRICK

STORET CODE:					97421
METHOD CODE:					I
PARAMETER:					LIPID %
UNITS:					
FLD.GRP.	#	SAMPLE ID	DATE	TIME	
DV1BAT	1	E3-BCK-F01	11/09/93	10:00	0.7
DV1BAT	2	E3-BCK-F02	11/07/93	10:00	1.3
DV1BAT	3	E3-BCK-F03	11/07/93	10:00	0.3
DV1BAT	4	E3-BCK-F04	11/07/93	10:00	0.6
DV1BAT	5	E3-BCK-F05	11/07/93	10:00	0.5
DV1BAT	6	E3-BCK-F06	11/09/93	10:00	0.6
DV1BAT	7	E3-BCK-F07	11/07/93	10:00	0.6
DV1BAT	8	E3-BCK-F08	11/07/93	10:00	0.5
DV1BAT	9	E3-GCK-F09	11/07/93	10:00	0.3
DV1BAT	10	E3-GCK-F10	11/07/93	10:00	1.1
DV1BAT	11	E3-BCK-F11	11/07/93	10:00	1.0
DV1BAT	12	E3-BCK-F12	11/07/93	10:00	0.8
DV1BAT	13	E3-BCK-F13	11/07/93	10:00	0.5
DV1BAT	14	E3-BCK-F14	11/07/93	10:00	0.7
DV1BAT	15	E3-PUF-F10	11/03/93	10:00	1.4
DV1BAT	16	E3-PUF-F11	11/03/93	10:00	0.8
DV1BAT	17	E3-PUF-F12	11/03/93	10:00	0.9
DV1BAT	18	E3-PUF-F13	11/03/93	10:00	0.7
DV1BAT	19	E3-PUF-F14	11/03/93	10:00	1.1
DV1BAT	20	E3-PUF-F15	11/03/93	10:00	0.6
DV1BAT	21	E3-PUF-F16	11/03/93	10:00	0.7
DV1BAT	22	E3-PUF-F17	11/02/93	16:00	0.4
DV1BAT	23	E3-PUF-F18	11/02/93	16:00	0.6
DV1BAT	24	E3-PUF-F19	11/03/93	10:00	0.5
DV1BAT	25	E3-PUF-F20	11/03/93	10:00	0.4
DV1BAT	26	E3-PUF-F21	11/03/93	10:00	0.9
DV1BAT	27	E3-PUF-F22	11/03/93	10:00	0.3
DV1BAT	28	E3-PUF-F23	11/03/93	10:00	0.5
DV1BAT	29	E3-PUF-F24	11/03/93	10:00	0.5
DV1BAT	30	E3-BCK-F15	11/07/93	10:00	0.4
DV1BAT	31	E3-BCK-F16	11/07/93	10:00	0.6
DV1BAT	32	E3-BCK-F17	11/09/93	15:00	0.6
DV1BAT	33	E3-BCK-F18	11/09/93	15:00	0.5
DV1BAT	34	E3-BCK-F19	11/09/93	15:00	0.7
DV1BAT	35	E3-PUF-F01	11/02/93	16:00	0.4
DV1BAT	36	E3-PUF-F02	11/02/93	16:00	0.8
DV1BAT	37	E3-PUF-F03	11/02/93	16:00	0.3
DV1BAT	38	E3-PUF-F04	11/02/93	16:00	0.8
DV1BAT	39	E3-PUF-F05	11/02/93	16:00	0.5
DV1BAT	40	E3-PUF-F06	11/03/93	10:00	0.5
DV1BAT	41	E3-PUF-F07	11/03/93	10:00	0.4
DV1BAT	42	E3-PUF-F08	11/03/93	10:00	0.7
DV1BAT	43	E3-PUF-F09	11/03/93	10:00	1.2

CHAIN OF CUSTODY RECORD

Ecology and Environment, Inc., Analytical Services Center
4285 Genesee Street, Buffalo, New York, 14225, Tel: (716) 631-0360
International Specialists In The Environment

PROJECT MANAGER: R KING
PHONE No: 703/ 522-6065
FIELD TEAM LEADER: C. EVAN
PHONE No.: 508/ 897-0095

COOLER NUMBER: 1 of 1
Page: 1 of 3

PROJECT No:	PROJECT NAME/CLIENT:	INSTALLATION	SITE INFORMATION:
VC-6076	SUDBURY / NNEX / ARMY	SD	LAB: ES SAMPLE PROG: C
SAMPLERS (SIGNATURE):		STATE: MA	PRIME CONT: EL

DATE	TIME	SITE ID	FIELD SAMPLE NUMBER	SITE TYPE	SAMPLE TYPE	SAMPLE TECH	DEPTH	E & E LAB SAMPLE NUMBER	No. of CONTAINERS	TCL VOAS	TCL BNAS	TCL PEST/[redacted]	TAL METALS/[redacted]	EXPLOSIVES	TPHC	ANIONS	TOC	GRAIN SIZE	% LIPIDS	CPG PHOS PEST
11/9	1000	E3-BCK-F01	FXBCK011	BIOL	AT	G	0		1			X	X						X	X
11/7	1000	E3-BCK-F02	FXBCK021	BIOL	AT	G	0		1			X	X						X	X
11/7	1000	E3-BCK-F03	FXBCK031	BIOL	AT	G	0		1			X	X						X	X
11/7	1000	E3-BCK-F04	FXBCK041	BIOL	AT	G	0		1			X	X						X	X
11/7	1000	E3-BCK-F05	FXBCK051	BIOL	AT	G	0		1			X	X						X	X
11/9	1000	E3-BCK-F06	FXBCK061	BIOL	AT	G	0		1			X	X						X	X
11/7	1000	E3-BCK-F07	FXBCK071	BIOL	AT	G	0		1			X	X						X	X
11/7	1000	E3-BCK-F08	FXBCK081	BIOL	AT	G	0		1			X	X						X	X
11/7	1000	E3-BCK-F09	FXBCK091	BIOL	AT	G	0		1			X	X						X	X
11/7	1000	E3-BCK-F10	FXBCK101	BIOL	AT	G	0		1			X	X						X	X
11/7	1000	E3-BCK-F11	FXBCK111	BIOL	AT	G	0		1			X	X						X	X
11/7	1000	E3-BCK-F12	FXBCK121	BIOL	AT	G	0		1			X	X						X	X
11/7	1000	E3-BCK-F13	FXBCK131	BIOL	AT	G	0		1			X	X						X	X
11/7	1000	E3-BCK-F14	FXBCK141	BIOL	AT	G	0		1			X	X						X	X

Remarks:

Relinquished By (Signature):	Date/Time	Received By (Signature):	Ship Via: FED EX	BL/Airbill Number:
			Date: 11/10/13	783375562
Relinquished By (Signature):	Date/Time: 11/10/13 1830	Received By (Signature):		

	YES	NO
Ice Present	☐	☐
Bottles Intact	☐	☐
Custody Seals	☐	☐

White: Laboratory Copy Canary: Field Leader Copy Pink: QA Coordinator Copy

0310693

CHAIN OF CUSTODY RECORD

Ecology and Environment, Inc., Analytical Services Center
4285 Genesee Street, Buffalo, New York, 14225, Tel: (716) 631-0360
International Specialists in The Environment

PROJECT MANAGER: R. KING
PHONE No: 703/522-6065
FIELD TEAM LEADER: C. EICH
PHONE No.: 508/897-0095

COOLER NUMBER: 1 of 1
Page: 2 of 3

PROJECT No: UC-6076
PROJECT NAME/CLIENT: SUDBURY ANNEX/ARMY
SAMPLERS (SIGNATURE):
INSTALLATION: SD
STATE: MA
SITE INFORMATION: LAB: ES; SAMPLE PROG: C
PRIME CONT: EL

DATE	TIME	SITE ID	FIELD SAMPLE NUMBER	SITE TYPE	SAMPLE TYPE	SAMPLE TECH	DEPTH	E & E LAB SAMPLE NUMBER	No. of CONTAINERS	TCL VOAS	TCL BNAS	TCL PEST/PCBs	TAL METALS/[redacted]	EXPLOSIVES	TPHC	ANIONS	TOC	GRAIN SIZE	% LIPIDS	PCB congeners
11/7	1000	E3-BCK-F15	FXBCK151	BIOL	AT	G	0		1			X	X						X	X
11/7	1000	E3-BCK-F16	FXBCK161	BIOL	AT	G	0		1			X	X						X	X
11/9	1500	E3-BCK-F17	FXBCK171	BIOL	AT	G	0		1			X	X						X	X
11/9	1500	E3-BCK-F18	FXBCK181	BIOL	AT	G	0		1			X	X						X	X
11/9	1500	E3-BCK-F19	FXBCK191	BIOL	AT	G	0		1			X	X						X	X
11/2	1600	E3-PUF-F01	FXPUF0011	BIOL	AT	G	0		1			X	X						X	X
11/2	1600	E3-PUF-F02	FXPUF0021	BIOL	AT	G	0		1			X	X						X	X
11/2	1600	E3-PUF-F03	FXPUF0031	BIOL	AT	G	0		1			X	X						X	X
11/2	1600	E3-PUF-F04	FXPUF0041	BIOL	AT	G	0		1			X	X						X	X
11/2	1600	E3-PUF-F05	FXPUF0051	BIOL	AT	G	0		1			X	X						X	X
11/3	1000	E3-PUF-F06	FXPUF0061	BIOL	AT	G	0		1			X	X						X	X
11/3	1000	E3-PUF-F07	FXPUF0071	BIOL	AT	G	0		1			X	X						X	X
11/3	1000	E3-PUF-F08	FXPUF0081	BIOL	AT	G	0		1			X	X						X	X
11/3	1000	E3-PUF-F09	FXPUF0091	BIOL	AT	G	0		1			X	X						X	X

Remarks:

Relinquished By (Signature):	Date/Time	Received By (Signature):	Ship Via: FED EX	BL/Airbill Number:
			Date: 11/12/93	983319556 2
Relinquished By (Signature):	Date/Time	Received By (Signature):		
	11/10/93 1830			

	YES	NO
Ice Present	☐	☐
Bottles Intact	☐	☐
Custody Seals	☐	☐

White: Laboratory Copy Canary: Field Leader Copy Pink: QA Coordinator Copy

0310693

CHAIN OF CUSTODY RECORD

Ecology and Environment, Inc., Analytical Services Center
4285 Genesee Street, Buffalo, New York, 14225, Tel: (716) 631-0360
International Specialists In The Environment

PROJECT MANAGER: R. KING
PHONE No: 703/522-6065
FIELD TEAM LEADER: C. EICH
PHONE No.: 508/877-0075

COOLER NUMBER: 1 of 1
Page: 3 of 3

PROJECT No:	PROJECT NAME/CLIENT:	INSTAL-LATION	SITE INFORMATION:
UC-6076	SUDBURY ANNEX/ARMY	SD	LAB: ES / SAMPLE PROG: C
SAMPLERS (SIGNATURE):		STATE: MA	PRIME CONT: EL

DATE	TIME	SITE ID	FIELD SAMPLE NUMBER	SITE TYPE	SAMPLE TYPE	SAMPLE TECH	DEPTH	E & E LAB SAMPLE NUMBER	No. of CONTAINERS	TCL VOAS	TCL BNAS	TCL PEST/PCBs	TAL METALS/[illegible]	EXPLOSIVES	TPHC	ANIONS	TOC	GRAIN SIZE	% LIPIDS	026 PHOS. TEST
11/3	1000	E3-PUF-F10	FXPUF101	BIOL	AT	G	0		1			X	X						X	X
11/3	1000	E3-PUF-F11	FXPUF111	BIOL	AT	G	0		1			X	X						X	X
11/3	1000	E3-PUF-F12	FXPUF121	BIOL	AT	G	0		1			X	X						X	X
11/3	1000	E3-PUF-F13	FXPUF131	BIOL	AT	G	0		1			X	X						X	X
11/3	1000	E3-PUF-F14	FXPUF141	BIOL	AT	G	0		1			X	X						X	X
11/3	1000	E3-PUF-F15	FXPUF151	BIOL	AT	G	0		1			X	X						X	X
11/3	1000	E3-PUF-F16	FXPUF161	BIOL	AT	G	0		1			X	X						X	X
11/2	1600	E3-PUF-F17	FXPUF171	BIOL	AT	G	0		1			X	X						X	X
11/2	1600	E3-PUF-F18	FXPUF181	BIOL	AT	G	0		1			X	X						X	X
11/3	1000	E3-PUF-F19	FXPUF191	BIOL	AT	G	0		1			X	X						X	X
11/3	1000	E3-PUF-F20	FXPUF201	BIOL	AT	G	0		1			X	X						X	X
11/3	1000	E3-PUF-F21	FXPUF211	BIOL	AT	G	0		1			X	X						X	X
11/3	1000	E3-PUF-F22	FXPUF221	BIOL	AT	G	0		1			X	X						X	X
11/3	1000	E3-PUF-F23	FXPUF231	BIOL	AT	G	0		1			X	X						X	X
11/3	1000	E3-PUF-F24	FXPUF241	BIOL	AT	G	0		1			X	X						X	X

Remarks:

Relinquished By (Signature):	Date/Time	Received By (Signature):	Ship Via: FED EX	BL/Airbill Number:
			Date: 11/10/93	9833195562
Relinquished By (Signature):	Date/Time: 11/10/93 1830	Received By (Signature):		

	YES	NO
Ice Present	☐	☐
Bottles Intact	☐	☐
Custody Seals	☐	☐

White: Laboratory Copy Canary: Field Leader Copy Pink: QA Coordinator Copy

0310693

APPENDIX D

ANALYTICAL DATA
SURFACE WATER AND SEDIMENT SAMPLES

The following tables present the results of chemical analyses of the surface water and sediment samples collected from Puffer Pond and Ministers Pond for this study. The analyses were performed by E & E's Analytical Services Center. The tables are followed by copies of the chain-of-custody forms maintained to ensure sample integrity from sample collection to analysis.

Date: 03/17/94
File Type: CSE
Site Type: POND

Appendix D
Chemical Summary Report For Sediments (Ministers Pond)
Background Pond
Units: UGG

	Site ID	E3-OFF-D01	E3-OFF-D02	E3-OFF-D03	E3-OFF-D04	E3-OFF-D05	E3-OFF-D06
	Field Sample ID	DXOFA011	DXOFA021	DXOFA031	DXOFA041	DXOFA051	DXOFA061
	Sample Date	11/09/93	11/09/93	11/09/93	11/09/93	11/09/93	11/09/93
Test	Parameter .						
TAL METAL	Aluminum	5740	3850	4720	2320	2050	4330
	Arsenic	3.33	3.46	3.85	2.10	3.40	9.56
	Barium	43.4	43.3	44.2	19.2	29.2	55.3
	Cadmium	0.669 BJ	2.06 KJ	0.863 BJ	< 0.500	< 0.500	0.924 BJ
	Calcium	3310	3550	3630	1640	2690	4550
	Chromium	12.8	9.81	10.6	5.20 J	5.33 J	11.3 J
	Cobalt	4.50	5.82	6.11	3.30	3.65 J	11.4
	Copper	8.10	7.70	9.00	4.56	4.47	10.9
	Iron	6240	6810	6790	4120	5720	16300
	Lead	23.7	34.7	37.5	11.5	17.2	49.4
	Magnesium	1480 J	948 J	1110 J	485 J	401 J	956 J
	Manganese	57.9	43.6	47.8	22.4	32.4	74.1
	Nickel	11.7	14.0	14.4	12.7	13.1	23.2
	Potassium	545 KJ	< 200	900 J	491 KJ	198 BJ	< 200
	Silver	< 0.200	< 0.200	< 0.200	0.605	0.879	< 0.200
	Sodium	492 J	531 J	239 KJ	< 200	278 J	778 J
	Vanadium	12.6	10.8	12.6	5.61 J	8.52	21.8
	Zinc	32.5	44.3	41.8	22.8	23.9	55.3
TCL Pest	P,P-DDD	0.390 C	0.063 C	0.110 C	0.022 JC	0.004 JC	0.060 JC
	P,P-DDE	0.074 C	< 0.010	0.037 JC	< 0.010	< 0.002	< 0.010
TOC	Total Organic Carbon	336000	433000	439000	488000	437000	577000

Source: USAEC IRDMIS Level 3/E & E, 1994 - Codes following values indicate data useability. (see below)

B= Attributable to field or laboratory contamination.
C= Confirmed on second column, U= Unconfirmed.
J= Estimated value. L= Result bias low.
K= Result bias high. R= Result rejected.

Date: 03/17/94
File Type: CSE
Site Type: POND

Appendix D
Chemical Summary Report For Sediments (Ministers Pond)
Background Pond
Units: UGG

	Site ID		E3-OFF-D04	E3-OFF-D05	E3-OFF-D05	E3-OFF-D06	E3-OFF-D06
	Field Sample ID		DXOFA041	DX0FF051	DXOFA051	DX0FF061	DXOFA061
	Sample Date		11/09/93	11/09/93	11/09/93	11/09/93	11/09/93
Test	Parameter .						
TAL METAL	Aluminum		2320		2050		4330
	Arsenic		2.10		3.40		9.56
	Barium		19.2		29.2		55.3
	Cadmium		< 0.500		< 0.500		0.924 BJ
	Calcium		1640		2690		4550
	Chromium		5.20 J		5.33 J		11.3 J
	Cobalt		3.30		3.65 J		11.4
	Copper		4.56		4.47		10.9
	Iron		4120		5720		16300
	Lead		11.5		17.2		49.4
	Magnesium		485 J		401 J		956 J
	Manganese		22.4		32.4		74.1
	Nickel		12.7		13.1		23.2
	Potassium		491 KJ		198 BJ		< 200
	Silver		0.605		0.879		< 0.200
	Sodium		< 200		278 J		778 J
	Vanadium		5.61 J		8.52		21.8
	Zinc		22.8		23.9		55.3
TCL Pest	P,P-DDD		0.022 JC		0.004 JC		0.060 JC
	P,P-DDE		< 0.010		< 0.002		< 0.010
TOC	Total Organic Carbon		488000		437000		577000

Source: USAEC IRDMIS Level 3/E & E, 1994 - Codes following values indicate data useability. (see below)

B= Attributable to field or laboratory contamination.
C= Confirmed on second column, U= Unconfirmed.
J= Estimated value. L= Result bias low.
K= Result bias high. R= Result rejected.

Date: 03/17/94
File Type: CSW
Site Type: POND

Appendix D
Chemical Summary Report For Surface Waters (Ministers Pond)
Background Pond
Units: UGL

	Site ID	E3-OFF-D01	E3-OFF-D02	E3-OFF-D03	E3-OFF-D04	E3-OFF-D05	E3-OFF-D06
	Field Sample ID	WXOFA011	WXOFA021	WXOFA031	WXOFA041	WXOFA051	WXOFA061
	Sample Date	11/09/93	11/09/93	11/09/93	11/09/93	11/09/93	11/09/93
Test	Parameter .						
TAL METAL	Aluminum	61.1	58.3	69.2	53.9	61.0	48.1
	Antimony	< 5.00	< 5.00	1.25 J	< 5.00	< 5.00	< 5.00
	Barium	12.2	11.9	12.4	14.0	13.4	11.9
	Calcium	8510	8180	8280	8730	8580	7910
	Cobalt	< 10.0	2.32 J	< 10.0	2.30 J	< 10.0	< 10.0
	Iron	992	954	966	1030	1110	1020
	Lead	1.08 J	0.910 J	0.890 J	1.39 J	3.02 J	< 5.00
	Magnesium	2200	2120	2140	2250	2220	2080
	Manganese	26.6	25.1	26.2	26.3	26.5	20.0
	Nickel	11.3	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0
	Potassium	3450	3220	3240	3420	3640	3200 K
	Sodium	17500	16500	16800	18000	18000	17800
	Zinc	67.8	53.6 K	60.9 K	22.6 B	30.4 K	9.33 BJ
	.						

Source: USAEC IRDMIS Level 3/E & E, 1994 - Codes following values indicate data useability. (see below)

B= Attributable to field or laboratory contamination.
C= Confirmed on second column, U= Unconfirmed.
J= Estimated value. L= Result bias low.
K= Result bias high. R= Result rejected.

Date: 03/17/94
File Type: CSW
Site Type: POND

Appendix D
Chemical Summary Report For Surface Waters (Ministers Pond)
Background Pond
Units: UGG

	Site ID	E3-OFF-D04		E3-OFF-D04	E3-OFF-D05	E3-OFF-D06	
	Field Sample ID	WX0FA041		WXOFA041	WXOFA051	WXOFA061	
	Sample Date	11/09/93		11/09/93	11/09/93	11/09/93	
Test	Parameter .						
TAL METAL	Aluminum			53.9	61.0	48.1	
	Antimony			< 5.00	< 5.00	< 5.00	
	Barium			14.0	13.4	11.9	
	Calcium			8730	8580	7910	
	Cobalt			2.30 J	< 10.0	< 10.0	
	Iron			1030	1110	1020	
	Lead			1.39 J	3.02 J	< 5.00	
	Magnesium			2250	2220	2080	
	Manganese			26.3	26.5	20.0	
	Nickel			< 10.0	< 10.0	< 10.0	
	Potassium			3420	3640	3200 K	
	Sodium			18000	18000	17800	
	Zinc			22.6 B	30.4 K	9.33 BJ	

Source: USAEC IRDMIS Level 3/E & E, 1994 - Codes following values indicate data useability. (see below)

B= Attributable to field or laboratory contamination.
C= Confirmed on second column, U= Unconfirmed.
J= Estimated value.
K= Result bias high.
L= Result bias low.
R= Result rejected.

Date: 03/17/94
File Type: CSE
Site Type: POND

Appendix D
Chemical Summary Report For Puffer Pond Sediments

Units: UGG

	Site ID	E3-PUF-D01	E3-PUF-D02	E3-PUF-D02	E3-PUF-D03	E3-PUF-D04	E3-PUF-D05
	Field Sample ID	DXPUF011	DDPUF021	DXPUF021	DXPUF031	DXPUF041	DXPUF051
	Sample Date	11/05/93	11/05/93	11/05/93	11/05/93	11/05/93	11/05/93
Test	Parameter						
TAL METAL	Aluminum	2800	6710	8170	7680	8390	3550
	Arsenic	9.64 J	34.1 J	32.7 J	37.1 J	40.9 J	23.1 J
	Barium	19.1	40.0 J	49.6	50.7 J	52.9 J	21.2 J
	Beryllium	< 0.500	< 0.500	< 0.500	< 0.500	0.491 J	< 0.500
	Cadmium	1.35 K	< 0.500 J	1.69 KJ	2.45 KJ	< 0.500 J	< 0.500 J
	Calcium	1280	5160	6430	5830 J	5840	2590 J
	Chromium	7.24	13.5 J	16.3 J	14.6 J	16.8 J	9.13 J
	Cobalt	3.91	9.66	12.3	9.89 J	14.8	3.60 J
	Copper	2.11 J	7.76 J	10.3	14.0	20.9	6.98
	Iron	5210	13900	17600	14600	15300	6280
	Lead	8.82	22.1	27.0	93.0	111	46.4
	Magnesium	979 J	829 J	1100 J	949 J	1000 J	526 J
	Manganese	63.2	161	204	181	189	65.1
	Nickel	5.21	12.7	16.7	22.7	18.3	7.97
	Potassium	526 K	950 J	458 KJ	1450 J	681 J	< 200
	Selenium	< 0.200	1.42 J	2.47	< 0.200	< 0.200	0.878 J
	Silver	< 0.200	< 0.200	< 0.200	3.05	< 0.200	< 0.200
	Sodium	96.8 BJ	428 J	491 J	< 200	709 J	< 200
	Vanadium	5.98	14.2 J	18.0	29.6	38.2	12.4
	Zinc	20.7	54.2	77.2	142	123	61.0
TCL Pest	P,P-DDD	< 0.010	< 0.010	0.065 JC	0.250 C	0.083 JC	0.110 C
	P,P-DDE	< 0.010	< 0.010 J	< 0.010	0.160 C	< 0.010	0.058 JC
TOC	Total Organic Carbon	22200	334000	336000	349000	372000	449000

Source: USAEC IRDMIS Level 3/E & E, 1994 - Codes following values indicate data useability. (see below)

B= Attributable to field or laboratory contamination.
C= Confirmed on second column, U= Unconfirmed.
J= Estimated value.
K= Result bias high.
L= Result bias low.
R= Result rejected.

Date: 03/17/94
File Type: CSE
Site Type: POND

Appendix D
Chemical Summary Report For Puffer Pond Sediments

Units: UGG

	Site ID	E3-PUF-D06					
	Field Sample ID	DXPUF061					
	Sample Date	11/05/93					
Test	Parameter .						
TAL METAL	Aluminum	8580					
	Arsenic	42.4 J					
	Barium	55.1					
	Beryllium	< 0.500					
	Cadmium	< 0.500 J					
	Calcium	7550					
	Chromium	16.5 J					
	Cobalt	11.4					
	Copper	15.1					
	Iron	17700					
	Lead	45.0					
	Magnesium	1010 J					
	Manganese	216					
	Nickel	20.0					
	Potassium	< 200					
	Selenium	< 0.200					
	Silver	2.87					
	Sodium	808 J					
	Vanadium	22.4					
	Zinc	96.4					
TCL Pest	P,P-DDD	0.110 C					
	P,P-DDE	0.071 JC					
TOC	Total Organic Carbon	335000					

Source: USAEC IRDMIS Level 3/E & E, 1994 - Codes following values indicate data useability. (see below)

B= Attributable to field or laboratory contamination.
C= Confirmed on second column, U= Unconfirmed.
J= Estimated value. L= Result bias low.
K= Result bias high. R= Result rejected.

Date: 03/17/94
File Type: CSW
Site Type: POND

Appendix D
Chemical Summary Report For Puffer Pond Surface Waters

Units: UGL

	Site ID	E3-PUF-D01	E3-PUF-D02	E3-PUF-D02	E3-PUF-D03	E3-PUF-D04	E3-PUF-D05
	Field Sample ID	WXPUF011	WDPUF021	WXPUF021	WXPUF031	WXPUF041	WXPUF051
	Sample Date	11/05/93	11/05/93	11/05/93	11/05/93	11/05/93	11/05/93
Test	Parameter						
TAL METAL	Aluminum	40.9	42.8	52.9	49.9	31.4	51.1
	Antimony	< 5.00	< 5.00	1.40 J	< 5.00	< 5.00	< 5.00
	Arsenic	1.83 J	2.83	1.81 J	2.53	1.77 J	1.84 J
	Barium	4.39 J	< 10.0	4.93 J	4.57 J	4.15 J	< 10.0
	Cadmium	< 5.00	3.06 J	< 5.00	< 5.00	< 5.00	< 5.00
	Calcium	3740	3730	3650	3820	3830	3850
	Chromium	2.95 J	3.13 J	< 10.0	< 10.0	< 10.0	< 10.0
	Iron	541	467	460	477	475	484
	Lead	1.55 J	3.25 J	1.71 J	2.42 J	1.65 J	1.70 J
	Magnesium	907	902	873	917	921	924
	Manganese	18.5	17.7	17.3	17.9	17.5	17.0
	Selenium	1.37 J	< 2.00	< 2.00	< 2.00	< 2.00	< 2.00
	Sodium	5910	6250	6020	6110	5970	6170

Source: USAEC IRDMIS Level 3/E & E, 1994 - Codes following values indicate data useability. (see below)

B= Attributable to field or laboratory contamination.
C= Confirmed on second column, U= Unconfirmed.
J= Estimated value. L= Result bias low.
K= Result bias high. R= Result rejected.

Date: 03/17/94
File Type: CSW
Site Type: POND

Appendix D
Chemical Summary Report For Puffer Pond Surface Waters

Units: UGL

	Site ID	E3-PUF-D06					
	Field Sample ID	WXPUF061					
	Sample Date	11/05/93					
Test	Parameter .						
TAL METAL	Aluminum	35.1					
	Antimony	< 5.00					
	Arsenic	2.35					
	Barium	< 10.0					
	Cadmium	< 5.00					
	Calcium	3770					
	Chromium	< 10.0					
	Iron	452					
	Lead	< 5.00					
	Magnesium	909					
	Manganese	16.8					
	Selenium	< 2.00					
	Sodium	6200					

Source: USAEC IRDMIS Level 3/E & E, 1994 - Codes following values indicate data useability. (see below)

B= Attributable to field or laboratory contamination.
C= Confirmed on second column, U= Unconfirmed.
J= Estimated value. L= Result bias low.
K= Result bias high. R= Result rejected.

CHAIN OF CUSTODY RECORD

Ecology and Environment, Inc., Analytical Services Center
4285 Genesee Street, Buffalo, New York, 14225, Tel: (716) 631-0360
International Specialists In The Environment

PROJECT MANAGER R. KING
PHONE No: 703/ 522-6065
FIELD TEAM LEADER C. EICH
PHONE No.: 508/ 897-0095

+ TOC

COOLER NUMBER: 1 of 2

Page: 1 of 2

PROJECT No: UC-6076
PROJECT NAME/CLIENT: SUDBURY ANNEX / ARMY
INSTALLATION: SD
SAMPLERS (SIGNATURE):
STATE: MA
SITE INFORMATION:
LAB: EL
SAMPLE PROG: C
PRIME CONT: E.L

DATE	TIME	SITE ID	FIELD SAMPLE NUMBER	SITE TYPE	SAMPLE TYPE	SAMPLE TECH	DEPTH	E & E LAB SAMPLE NUMBER	No. of CONTAINERS	TCL VOAS	TCL BNAS	TCL PEST/PCBs	TAL METALS/HARD	EXPLOSIVES	TPHC	ANIONS	TOC	GRAIN SIZE	TAL METALS	
11/5	1034	E3-PUF-D01	WXPUF011	POND	SW	G	0		7			4							3	
11/5	1034	E3-PUF-D01	DXPUF011	POND	SE	G	0		4			2	2							
11/5	1100	E3-PUF-D02	WXPUF021	POND	SW	G	0		3			2							1	
11/5	1100	E3-PUF-D02	DXPUF021	POND	SE	G	0		2			1	1							
11/5	1100	E3-PUF-D02	WDPUF021	POND	SW	G	0		3			2							1	
11/5	1100	E3-PUF-D02	DDPUF021	POND	SE	G	0		2			1	1							
11/5	1124	E3-PUF-D03	WXPUF031	POND	SW	G	0		3			2							1	
11/5	1124	E3-PUF-D03	DXPUF031	POND	SE	G	0		2			1	1							
11/5	1124	E3-PUF-D03	DRPUF031	RNSW	SE	G	0		3			2							1	*
11/5	1142	E3-PUF-D04	WXPUF041	POND	SW	G	0		3			2							1	
11/5	1142	E3-PUF-D04	DXPUF041	POND	SE	G	0		2			1	1							
11/5	1215	E3-PUF-D05	WXPUF051	POND	SW	G	0		3			2							1	
11/5	1215	E3-PUF-D05	DXPUF051	POND	SE	G	0		2			1	1							
11/5	1235	E3-PUF-D06	WXPUF061	POND	SW	G	0		3			2							1	

Remarks: * FIELD SAMPLE NO. - DRPUF011

Relinquished By (Signature):	Date/Time	Received By (Signature):	Ship Via: FED EX	BL/Airbill Number:
			Date: 11/5/93	0800930701
Relinquished By (Signature):	Date/Time: 11/5/93 1830	Received By (Signature):	Ice Present ☐ YES ☐ NO	
			Bottles Intact ☐ ☐	
			Custody Seals ☐ ☐	

White: Laboratory Copy Canary: Field Leader Copy Pink: QA Coordinator Copy

0310693

CHAIN OF CUSTODY RECORD

Ecology and Environment, Inc., Analytical Services Center
4285 Genesee Street, Buffalo, New York, 14225, Tel: (716) 631-0360
International Specialists In The Environment

PROJECT MANAGER: R. KING
PHONE No: 703/ 522-1065
FIELD TEAM LEADER: C. EICH
PHONE No.: 508/ 897-0095

COOLER NUMBER: 2 of 2
Page: 2 of 2

PROJECT No:	PROJECT NAME/CLIENT:	INSTAL-LATION	SITE INFORMATION:	
UC-6076	SUDBURY ANNEX/ ARMY	SD	LAB: ES	SAMPLE PROG: C
SAMPLERS (SIGNATURE):		STATE: MA	PRIME CONT: EL	

DATE	TIME	SITE ID	FIELD SAMPLE NUMBER	SITE TYPE	SAMPLE TYPE	SAMPLE TECH	DEPTH	E & E LAB SAMPLE NUMBER	No. of CONTAINERS	TCL VOAS	TCL BNAS	TCL PEST/PCBS	TAL METALS/HARD + TOC	EXPLOSIVES	TPHC	ANIONS	TOC	GRAIN SIZE		
11/5	1235	~~SS~~ E3-PUF-D~~0~~	DXPUF061	POND	SE	G	00		2			1	1							

Remarks:

Relinquished By (Signature):	Date/Time	Received By (Signature):	Ship Via: FEX EX	BL/Airbill Number:
			Date: 11/5/93	080093070 1
Relinquished By (Signature):	**Date/Time**	**Received By (Signature):**		YES / NO
	11/5/93 1830		Ice Present ☐ ☐	
			Bottles Intact ☐ ☐	
			Custody Seals ☐ ☐	

White: Laboratory Copy Canary: Field Leader Copy Pink: QA Coordinator Copy

0310693

CHAIN OF CUSTODY RECORD

Ecology and Environment, Inc., Analytical Services Center
4285 Genesee Street, Buffalo, New York, 14225, Tel: (716) 631-0360
International Specialists In The Environment

PROJECT MANAGER: R. KING
PHONE No: 703/522-6065
FIELD TEAM LEADER: C. EICH
PHONE No.: 508/897-0075

COOLER NUMBER: 1 of 1
Page: 1 of 2

PROJECT No: UC-6076
PROJECT NAME/CLIENT: SUDBURY ANNEX - ARMY
INSTALLATION: SD
SAMPLERS (SIGNATURE):
STATE: MA
SITE INFORMATION:
LAB: ES
SAMPLE PROG: C
PRIME CONT: EL

DATE	TIME	SITE ID	FIELD SAMPLE NUMBER	SITE TYPE	SAMPLE TYPE	SAMPLE TECH	DEPTH	E & E LAB SAMPLE NUMBER	No. of CONTAINERS	TCL VOAS	TCL BNAS	TCL PEST/PCBs	TAL METALS/HARD	EXPLOSIVES	TPHC	ANIONS	TOC	GRAIN SIZE	OPS PHOS PEST
11/5	10:34	E3-PUF-D01	WXPUF011	POND	SW	G	0		4*										4*
11/5	"	E3-PUF-D01	DXPUF011	POND	SE	G	0		2										2**
11/5	11:00	E3-PUF-D02	WXPUF021	POND	SW	G	0		2										2
11/5	"	E3-PUF-D02	WDPUF021	POND	SW	G	0		2										2
11/5	"	E3-PUF-D02	DXPUF021	POND	SE	G	0		1										1
11/5	"	E3-PUF-D02	DDPUF021	POND	SE	G	0		1										1
11/5	11:24	E3-PUF-D03	WXPUF031	POND	SW	G	0		2										2
11/5	"	E3-PUF-D03	DXPUF031	POND	SE	G	0		1										1
11/5	"	E3-PUF-D03	DRPUF011	POND (RNSW)	SE	G	0		2										2
11/5	11:17	E3-PUF-D04	WXPUF041	POND	SW	G	0		2										2
11/5	"	E3-PUF-D04	DXPUF041	POND	SE	G	0		1										1
11/5	12:15	E3-PUF-D05	WXPUF051	POND	SW	G	0		2										2
11/5	"	E3-PUF-D05	DXPUF051	POND	SE	G	0		1										1
11/5	12:35	E3-PUF-D06	WXPUF061	POND	SW	G	0		2										2

Remarks: * 4-CONTAINERS - INCLUDES VOLUMES FOR MS/MSD
** - 2-CONTAINERS - INCLUDES VOLUME FOR MS/MSD

Relinquished By (Signature):	Date/Time	Received By (Signature):	Ship Via: FED EX	BL/Airbill Number:
			Date: 11-5-97	983195573
Relinquished By (Signature):	Date/Time: 11/5/97 1830	Received By (Signature):		

	YES	NO
Ice Present	☐	☐
Bottles Intact	☐	☐
Custody Seals	☐	☐

White: Laboratory Copy Canary: Field Leader Copy Pink: QA Coordinator Copy

0310693

CHAIN OF CUSTODY RECORD

Ecology and Environment, Inc., Analytical Services Center
4285 Genesee Street, Buffalo, New York, 14225, Tel: (716) 631-0360
International Specialists In The Environment

PROJECT MANAGER: R. KING
PHONE No: 703/522-6065
FIELD TEAM LEADER: C. EICH
PHONE No.: 508/897-0095

COOLER NUMBER: 1 of 1
Page: 2 of 2

PROJECT No:	PROJECT NAME/CLIENT:	INSTALLATION	SITE INFORMATION:
VC-6076	SUDBURY ANNEX/ARMY	SD	LAB: ES / SAMPLE PROG: C
SAMPLERS (SIGNATURE):		STATE: MA	PRIME CONT: EL

DATE	TIME	SITE ID	FIELD SAMPLE NUMBER	SITE TYPE	SAMPLE TYPE	SAMPLE TECH	DEPTH	E & E LAB SAMPLE NUMBER	No. of CONTAINERS	TCL VOAS	TCL BNAS	TCL PEST/PCBs	TAL METALS/HARD	EXPLOSIVES	TPHC	ANIONS	TOC	GRAIN SIZE	ORG. PHOS PEST
11/5	12:35	E3-PUF-D06	DXPUF061	POND	SE	G	0		1										1

Remarks:

Relinquished By (Signature):	Date/Time	Received By (Signature):	Ship Via: FED EX	BL/Airbill Number:
			Date: 11/5/93	9833195573
Relinquished By (Signature):	Date/Time	Received By (Signature):		YES / NO
	11/5/93 1830		Ice Present ☐ ☐	
			Bottles Intact ☐ ☐	
			Custody Seals ☐ ☐	

White: Laboratory Copy Canary: Field Leader Copy Pink: QA Coordinator Copy

0310693

CHAIN OF CUSTODY RECORD

Ecology and Environment, Inc., Analytical Services Center
4285 Genesee Street, Buffalo, New York, 14225, Tel: (716) 631-0360
International Specialists In The Environment

PROJECT MANAGER: R. KING
PHONE No: 703/522-6065
FIELD TEAM LEADER: C. EICH
PHONE No.: 508/897-0095

COOLER NUMBER: 1 of 2
Page: 1 of 1

+ TOC

PROJECT No: UC-6076
PROJECT NAME/CLIENT: SUDBURY ANNEX / ARMY
SAMPLERS (SIGNATURE):
INSTALLATION: SD
STATE: MA
SITE INFORMATION: LAB: EL; SAMPLE PROG: C; PRIME CONT: EL

DATE	TIME	SITE ID	FIELD SAMPLE NUMBER	SITE TYPE	SAMPLE TYPE	SAMPLE TECH	DEPTH	E & E LAB SAMPLE NUMBER	No. of CONTAINERS	TCL VOAS	TCL BNAS	TCL PEST	TAL METALS	EXPLOSIVES	TPHC	ANIONS	TOC	GRAIN SIZE	TAL METALS
11/9	1120	E3-OFA-D01	WXOFA011	POND	SW	G	0		3			2							-
11/9	1120	E3-OFA-D01	DXOFA011	POND	SE	G	0		2			1	1						
11/9	1105	E3-OFA-D02	WXOFA021	POND	SW	G	0		3			2							1
11/9	1105	E3-OFA-D02	DXOFA021	POND	SE	G	0		2			1	1						
11/9	1035	E3-OFA-D03	WXOFA031	POND	SW	G	0		3			2							1
11/9	1035	E3-OFA-D03	DXOFA031	POND	SE	G	0		2			1	1						
11/9	1050	E3-OFA-D04	WXOFA041	POND	SW	G	0		3			2							1
11/9	1050	E3-OFA-D04	DXOFA041	POND	SE	G	0		2			1	1						
11/9	1135	E3-OFA-D05	WXOFA051	POND	SW	G	0		3			2							1
11/9	1135	E3-OFA-D05	DXOFA051	POND	SE	G	0		2			1	1						
11/9	1200	E3-OFA-D06	WXOFA061	POND	SW	G	0		3			2							1
11/9	1200	E3-OFA-D06	DXOFA061	POND	SE	G	0		2			1	1						
11/9																			
11/9																			

11-9-93

Remarks:

Relinquished By (Signature):	Date/Time	Received By (Signature):	Ship Via: FED EX	BL/Airbill Number:
			Date: 11/9/93	0800930690
Relinquished By (Signature):	Date/Time	Received By (Signature):		YES / NO
	11/9/93 1830		Ice Present ☐ ☐	
			Bottles Intact ☐ ☐	
			Custody Seals ☐ ☐	

White: Laboratory Copy Canary: Field Leader Copy Pink: QA Coordinator Copy

0310693

CHAIN OF CUSTODY RECORD

Ecology and Environment, Inc., Analytical Services Center
4285 Genesee Street, Buffalo, New York, 14225, Tel: (716) 631-0360
International Specialists In The Environment

PROJECT MANAGER: R. King
PHONE No: 703/ 522-6065
FIELD TEAM LEADER: C. Eich
PHONE No.: 508/ 897-0095

COOLER NUMBER: 1 of ____
Page: 1 of ____

PROJECT No: UC-6076
PROJECT NAME/CLIENT: SUDBURY ANNEX/ ARMY
INSTALLATION: SD
STATE: MA
SAMPLERS (SIGNATURE): [signature]
SITE INFORMATION: LAB: ES; SAMPLE PROG: C; PRIME CONT: EL

DATE	TIME	SITE ID	FIELD SAMPLE NUMBER	SITE TYPE	SAMPLE TYPE	SAMPLE TECH	DEPTH	E & E LAB SAMPLE NUMBER	No. of CONTAINERS	TCL VOAS	TCL BNAS	TCL PEST/PCBs	TAL METALS/HARD	EXPLOSIVES	TPHC	ANIONS	TOC	GRAIN SIZE	PEST ORG. PHOS
11/9	1120	E3-OFA-D01	WXOFAØ11	POND	SW	G	Ø		2										2
11/9	1120	E3-OFA-D01	DXOFAØ11	POND	SE	G	Ø		1										1
11/9	1105	E3-OFA-D02	WXOFAØ21	POND	SW	G	Ø		2										2
11/9	1105	E3-OFA-D02	DXOFAØ21	POND	SE	G	Ø		1										1
11/9	1035	E3-OFA-D03	WXOFAØ31	POND	SW	G	Ø		2										2
11/9	1035	E3-OFA-D03	DXOFAØ31	POND	SE	G	Ø		1										1
11/9	1050	E3-OFA-D04	WXOFAØ41	POND	SW	G	Ø		2										2
11/9	1050	E3-OFA-D04	DXOFAØ41	POND	SE	G	Ø		1										1
11/9	1135	E3-OFA-D05	WXOFAØ51	POND	SW	G	Ø		2										2
11/9	1135	E3-OFA-D05	DXOFAØ51	POND	SE	G	Ø		1										1
11/9	1200	E3-OFA-D06	WXOFAØ61	POND	SW	G	Ø		2										2
11/9	1200	E3-OFA-D06	DXOFAØ61	POND	SE	G	Ø		1										1

11-9-93

Remarks:

Relinquished By (Signature):	Date/Time	Received By (Signature):	Ship Via: FEX EX	BL/Airbill Number:
			Date: 11/9/93	983319 5584
Relinquished By (Signature): [signature]	**Date/Time** 11/9/93 1830	**Received By (Signature):**		

	YES	NO
Ice Present	☐	☐
Bottles Intact	☐	☐
Custody Seals	☐	☐

White: Laboratory Copy Canary: Field Leader Copy Pink: QA Coordinator Copy

0310693